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THE RAVENSWOOD GRANODIORITE

BY VICTOR ZIEGLER [1]

(Presented before the Academy, 6 March, 1911)

CONTENTS

GEOLOGICAL SECTION OF NEW YORK CITY

In the New York City folio of the United States Geological Survey, the following succession of formations is recognized: Fordham gneiss, Inwood limestone, called Stockbridge dolomite, and Manhattan schist, called Hudson schist. In addition, there are several minor intrusive masses, of which two, the Harrison diorite and the Yonkers gneiss, are large. The former is located along the eastern side of Westchester County, and the latter, immediately east of the city of Yonkers. To these two large intrusives, we may now add a third, exposed along the western shore of Long Island and first recognized by James F. Kemp,[2] who, in a paper describing the section of the rocks revealed by a tunnel beneath the East River, applied the name "Ravenswood granodiorite" to it. Subsequent field work and the exploratory borings undertaken by various engineering enterprises have proved the importance of this intrusive.

[1] The writer takes pleasure in acknowledging his obligation to Professor James F. Kemp, and especially to Professor C. P. Berkey, for aid in securing data and for many kind and helpful suggestions.

[2] Trans. N. Y. Acad. Sci., vol. 14, p. 273.

Surface Distribution of the Ravenswood Granodiorite

The western part of Long Island is covered by drift, so that exposures of rock are rare, except along the shore of the East River and about the Blackwell's Island bridge. Here is found a series of scattering outcrops, beginning near the corner of Boulevard and Potter Avenues and recurring at intervals as far south as Fifth Street. North and south of the above areas, drift masks everything, and the only clue to the underlying formations is afforded by a series of bore-holes which will be described later. In the New York City folio, most of the exposures of this rock are mapped as separate acidic intrusives in the Fordham, but the idea that these represented one large igneous body was not expressed. Since there are no traces of Fordham gneiss found between the above exposures, and since in a number of cases granodiorite was found between some of the outcrops in the excavations for the foundations of buildings, it seems to the writer that we may safely map this whole area as granodiorite. Thus we cut off at once an area of at least a square mile from the old Fordham formation and add it to the series of igneous intrusives mentioned above.

Petrographic Description

The Ravenswood granodiorite is a light to dark gray rock, varying from granitoid to gneissic in texture and ranging from a hornblende-biotite-granite to a diorite in composition. Garnet is present in nearly all specimens and in some cases is very abundant. For the purpose of establishing a type composition for the rock, the following table has been prepared to show the minerals present in a number of slides. A system of notation devised by C. P. Berkey, in which X denotes an essential, Y an accessory and Z a secondary mineral, is used.

Mineral Occurrences in the Granodiorite

Thin section.	Quartz.	Orthoclase.	Microcline.	Oligoclase.	Hornblende.	Augite.	Biotite.	Garnet.	Titanite.	Zircon.	Apatite.	Pyrite.	Pyrrhotite.	Magnetite.	Sec. Carbonates.	Kaolin.
1....	....	X	....	X	X	X	Y	X	Y	Y	Y	....	Y	....	Z	Z
2....	X	....	....	....	Y	....	Y	X	Y	Y	Y	Y	....	....	Z	....
3....	X	X	....	X	X	....	X	Y	Y	Y	Y	Y	....	Y	Z	Z
4....	X	Y	....	X	X	X	X	....	Y	Y	Y	....	Y	Y	Z	Z
5....	X	X	Y	Y	....	....	X	Y	Y	Y	Y	....	Y	....	....	Z
6....	Y	Y	....	X	X	....	X	Y	Y	Y	Y	Y	....	Y	Z	Z
7....	X	X	Y	X	X	....	Y	Y	Y	Y	Y	....	....	Y	Z	....
8....	....	Y	....	X	X	....	X	Y	Y	Y	Y	....	....	Y	....	Z
9....	X	X	....	Y	X	....	X	Y	Y	Y	Y	....	Y	....	....	Z
10....	X	X	....	Y	X	....	X	Y	Y	Y	Y	....	Y	....	Z	Z
11....	X	X	....	X	X	....	X	....	Y	Y	Y	....	....	....	....	Z
12....	X	X	....	Y	X	....	X	Y	Y	Y	Y	Y	....	Y	Z	Z
13....	X	X	Y	Y	X	....	X	Y	Y	Y	Y	....	....	....	Z	Z
14....	X	X	....	X	X	....	X	Y	Y	Y	Y	Y	....	....	....	Z
15....	X	X	Y	Y	X	....	X	Y	Y	Y	Y	....	....	....	Z	....
16....	X	Y	X	X	X	....	X	Y	Y	Y	Y	....	....	....	....	....
17....	X	Y	....	X	X	....	X	X	Y	Y	Y	....	....	Y	....	....
18....	X	X	....	X	X	....	X	Y	Y	Y	Y	....	....	Y	....	Z
19....	X	X	X	Y	X	....	X	Y	Y	Y	Y	Y	....	....	Z	....
20....	X	X	Y	Y	....	....	X	Y	Y	Y	Y	Y	....	Y	Z	Z

A summary of these occurrences for each individual constituent is as follows, F denoting the absence of the mineral from the slide:

Quartz..................................	17 X	1 Y	0 Z	2 F
Orthoclase..............................	14 X	3 Y	0 Z	1 F
Microcline..............................	2 X	5 Y	0 Z	13 F
Oligoclase..............................	11 X	8 Y	0 Z	1 F
Hornblende..............................	17 X	1 Y	0 Z	2 F
Augite..................................	2 X	0 Y	0 Z	18 F
Biotite.................................	17 X	3 Y	0 Z	0 F

Garnet	3 X	15 Y	0 Z	2 F
Titanite	0 X	20 Y	0 Z	0 F
Zircon	0 X	20 Y	0 Z	0 F
Apatite	0 X	20 Y	0 Z	0 F
Pyrite	0 X	7 Y	0 Z	13 F
Pyrrhotite	0 X	5 Y	0 Z	15 F
Magnetite	0 X	9 Y	0 Z	11 F
Carbonates	0 X	0 Y	12 Z	8 F
Kaolin	0 X	0 Y	14 Z	6 F

From this summary, we see that quartz, orthoclase, oligoclase, hornblende and biotite are the essential minerals, and that garnet, titanite, zircon and apatite are the common accessories, while microcline, anorthoclase, augite, pyrite, pyrrhotite and magnetite are rarer. The acid minerals are dominant.

Granite Phase

The hand specimen shows a medium dark gray rock, evenly and finely granitoid in texture and essentially composed of quartz, feldspar, hornblende and mica. Pink garnets of small size are present throughout the specimen and give it a mottled appearance. The rock is slightly gneissoid. The feldspars are fresh and semi-transparent and show polysynthetic twinning. The hornblende is a dark green variety, sometimes almost black.

Under the microscope, great differences in the size of grains are noticed, and there is also a tendency for the smaller grains of quartz and feldspar to surround the larger ones. The small individuals seem to be the result of the crushing to which the rock was subjected. Fractures are common in the rock and are coated with limonite and in some cases with quartz. The following minerals have been identified in the slide: quartz, orthoclase, anorthoclase and hornblende as essential minerals, also microcline, oligoclase, garnet, titanite, apatite, zircon, augite, magnetite and pyrite. Secondary alteration is slight, although limonite and kaolin are noticeable.

The quartz occurs allotriomorphically and also as small elongated prisms included in the feldspars. The latter case show between crossed nicols a fine rim of interference colors. Included in the quartz are zircon, apatite, biotite and fine trails of dust. Some of the quartzes have deep embayments and irregular outlines due to resorption. Nearly all show wavy extinction.

The predominant feldspar is orthoclase. This is, as a rule, allotriomorphic. Microperthitic structure is faintly developed. Carlsbad twins are common. Cleavage parallel to (010) is well marked, not so strong

parallel to (001). Several grains of microcline are present usually showing, between crossed nicols, the characteristic "Scotch-plaid" structure. The plagioclase is of the oligoclase type and is twinned according to the albite law, although some patches are twinned under the pericline law in addition. The bands due to the latter law are commonly the wider. Inclusions of all the other minerals occur.

The hornblende is a dark green variety, in irregular shreds and grains. Good cleavage is shown parallel to (110) and strong absorption along this. The pleochroism is intense, ranging from dark olive green to light green to yellowish brown. The extinction angle is 21 degrees.

Light green augite is present. It has weak pleochroism and an extinction angle of 36 degrees. Uralitization has developed, and the greater part of the augite has gone over into green hornblende. This uralite closely resembles the other hornblende in the rock in appearance and in optical properties. Both augite and hornblende seem to be primary minerals, and the alteration of the augite seems to be the result of the pressure which is also suggested by the wavy extinction and the crushed rims.

Brown biotite is present in small amounts, some of it as an alteration product of the hornblende. It then spreads along the cracks towards the center of the grains of hornblende. It is also present in small shreds and in lath-shaped crystals and often occurs in beautiful aggregates.

The garnet in this type of the rock is light red in color, pale pink in thin sections. It is associated with the darker minerals.

Magnetite and pyrite are usually present in small amounts. Titanite, zircon and apatite are found in all slides.

Chemical analysis:

	Per cent
SiO_2	75.61
Al_2O_3	12.53
Fe_2O_3	2.22
FeO	.86
MgO	.20
CaO	1.35
K_2O	3.18
Na_2O	5.21
H_2O	.09
	101.25

Recasting into the component minerals we obtain

	Per cent
Quartz	31.62
Orthoclase	16.68
Albite	44.02

	Per cent
Anorthite	.83
Grossularite	1.35
Almandite	1.49
Hornblende	2.83
Biotite	1.17
Hematite	1.28
	101.27

Diorite Phase

From this highly acidic type, the Ravenswood rock varies through intermediate stages to a quartz-diorite. It is then darker gray in color, medium in grain and slightly gneissic in structure. The mass of the rock is made up of oligoclase, green hornblende, brown biotite and garnet. Under the microscope, orthoclase, augite, zircon, titanite, apatite, pyrrhotite, pyrite, magnetite and kaolin were also identified. Here, as in the more acid type, the rock is granitoid with the component grains irregular in outline and interlocking. In size, they average about .8 to 1 mm. in diameter.

Oligoclase is the predominent feldspar. Polysynthetic twinning is shown, sections parallel to which have extinction angles of about seven degrees. Pericline twinning and Carlsbad twinning also occur, and in several cases all three are in combination. Strong wavy extinction is shown. Inclusions of hornblende, biotite, apatite, zircon and pyrrhotite are common.

The hornblende and the augite are of the same type as described in the granite phase and show the same alteration. The alteration of the augite is especially well shown. This takes place from the edges of the grains toward the center, but in some cases the change has taken place throughout the entire grain, the surface of which is spotted and blotchy from the formation of hornblende.

A chemical analysis of the typical diorite rock gave the following result:

	Per cent
SiO_2	64.98
Al_2O_3	20.51
Fe_2O_3	.50
FeO	2.35
MgO	.93
CaO	4.23
K_2O	1.84
Na_2O	5.22
H_2O	.11
	100.67

Recasting into the component minerals we obtain

	Per cent
Quartz	18.48
Orthoclase	8.34
Albite	44.02
Anorthite	13.90
Grossularite	2.25
Almandite	3.48
Hornblende and Augite	7.27
Biotite	1.05
Corundum	.91 [3]
Magnetite	.70

Probable Extent of the Ravenswood Granodiorite as Disclosed by Borings

Aside from the actual outcrops of the granodiorite so far discussed, records of it are found in borings undertaken in the drift-covered areas. Thus, north of the exposures and slightly southeast of Lawrence Point the Consolidated Gas Company of New York while drilling for water put down an eighteen-hundred foot borehole. The entire core is the typical Ravenswood rock. Again, south of the actual exposures, a series of borings[4] is now available from the corner of Myrtle Avenue and Gold Street. Brooklyn, across the East River into Manhattan, as far as Hester and Allen Streets. Several other drill records are also known as depicted on the map. In all of these, the core is a massive gray rock, in all respects like the exposed Ravenswood. It has the same appearance, texture and mineral composition, and it seems to be a part of the same igneous mass. Whether the rock is actually continuous so as to include all these areas, cannot be said with certainty, but the conclusion seems probable, and the corresponding extent has been so indicated on the accompanying map.

Origin of the Garnet

Some of the cores brought up on the above line and located near the intersection of John and Bridge Streets show a highly garnetiferous rock, reddish-brown in color. The rock is finely granitoid. Under the microscope, the following minerals were found: garnet and quartz as essential, also some feldspar, which varied extremely in different specimens, and

[3] The corundum molecule in this and the following analyses is probably to a great extent contained in the biotite.

[4] The borings and cores here referred to, samples from which were made available for this study, belong to the series of explorations made by the New York City Board of Water Supply along the proposed line of the distribution conduit for Catskill water.

some biotite, hornblende, titanite, apatite. pyrite and zircon. The garnet occurs in small grains closely bunched and cemented by quartz. They appear to be the crushed fragments of originally large garnets.

An analysis gave

	Per cent
SiO_2	52.82
Al_2O_3	22.75
Fe_2O_3	1.99
FeO	9.50
MgO	2.15
CaO	7.43
K_2O	.86
Na_2O	1.23
H_2O	.14
	98.87

Recasting into the component minerals we obtain

	Per cent
Quartz	22.44
Orthoclase	2.78
Albite	10.48
Anorthite	8.34
Grossularite	13.50
Almandite	14.94
Hornblende	22.13
Biotite	1.53
Corundum	.82
Ferric oxide	2.08

Glancing over the analysis, we see that this variety of the rock is very low in silica, as compared with the other two phases. It is high in alumina, lime and ferrous oxide. The latter three constituents are in the garnet, thus making it a composite of the grossularite and almandite molecules. There is also a decrease in the amount of soda and potash. On the whole, the rock has the appearance of a contact zone developed from an aluminous and ferruginous limestone, which furnished part of the lime, alumina and iron necessary for the formation of the garnet. Or else the aggregate may be due to the absorption of a mass of impure limestone in the granodiorite. Since Professor Berkey has shown that there are interbedded limestones practically everywhere in the Fordham gneiss, this explanation seems to the writer to be the best. According to Van Hise,[5] combined contact and mechanical action furnish the most favorable conditions for the formation of garnets, which are usually the

[5] Monograph on "Metamorphism," p. 300.

result of the rearrangement of two or more adjacent minerals. It is difficult to say just what minerals formed the garnet occurring so extensively throughout the granodiorite, but the following reactions are offered.

$$\begin{array}{ccccccc} \text{Anorthite} & + & \text{wollastonite} & = & \text{grossularite} & + & \text{quartz} \\ CaO,Al_2O_3,2SiO_2 & + & 2(CaO,SiO_2) & = & 3CaO,Al_2O_3,3SiO_2 & + & SiO_2 \end{array}$$

$$\begin{array}{ccccccc} \text{Anorthite} & + & \text{hypersthene} & = & \text{garnet} & + & \text{quartz} \\ CaO,Al_2O_3,2SiO_2 & + & 2((MgFe)O,SiO_2) & = & CaO,2(MgFe)O,Al_2O_3,3SiO_2 & + & SiO_2 \end{array}$$

$$\begin{array}{ccccc} \text{Pyroxene} & + & \text{anorthite} & = & \text{amphibole-} \\ (MgFe)O,(AlFe)_2O_3,SiO_2,2(MgO,SiO_2) & + & 2(CaO,Al_2O_3,2SiO_2) & = & 2(CaO)(MgFe)O, \end{array}$$

$$\begin{array}{ccccc} \text{pyroxene molecule} & + & \text{garnet} & + & \text{quartz} \\ (AlFe)_2O_3,3SiO_2 & + & 2(MgO,Al_2O_3,SiO_2) & + & 3SiO_2 \end{array}$$

Starting with orthoclase, the following reaction might take place.

$$\begin{array}{l} \text{Orthoclase} + \text{pyroxene} + \text{wollastonite} + \text{hypersthene} + \\ K_2O,Al_2O_3,6SiO_2 + 2((MgFe)O,(AlFe)_2O_3,SiO_2) + 2(CaO,SiO_2) + (MgFe)O,SiO_2 + \\ \text{water} \quad \text{garnet} + \text{biotite} + \\ H_2O = 2CaO,(MgFe)O,Al_2O_3,3SiO_2 + 2((HK)O,(AlFe)_2O_3,2SiO_2)2((MgFe)O,SiO_2) + \\ \text{quartz} \\ 3SiO_2 \end{array}$$

Yielding in this last case a complex garnet, biotite and quartz.

COMPARISON WITH THE HARRISON GRANODIORITE

A comparison of the Ravenswood granodiorite with the Harrison granodiorite as described by H. Ries[6] was made for the purpose of determining any relationship which might exist between the two rocks. Professor Ries says, regarding the Harrison diorite,

"Throughout its extent, the rock has a pronounced gneissic structure. Strong effects of folding and crushing with the consequent formation of 'augen' of quartz and feldspar are shown. The rock varies from a more or less massive gneiss . . . to a mica-schist. The minerals forming the granite are quartz, plagioclase, biotite, hornblende, orthoclase, and in lesser amounts garnet, titanite, zircon, apatite, muscovite, and microline.

"Quartz composes from two fifths to one half of the rock. It occurs in grains and in rounded masses, filling the spaces between the other minerals. The grains are often cracked and show undulatory extinction and zonal structure. Dustlike inclusions are often present and are arranged in more or less parallel rows, which often extend across the cracks from one grain to another. Intergrowths with plagioclase are not uncommon, especially around the edges of the feldspar augen.

"The plagioclase is rich in inclusions of biotite, apatite, and zircon, but

[6] Trans. N. Y. Acad. Sci., vol. xiv, p. 80.

smaller undeterminable ones are present in countless numbers. Some of the plagioclases show microperthitic structure.

"Orthoclase is less abundant than the quartz and the plagioclase. Microcline is rare. Biotite composes about one half of the rock. Hornblende is less in amount than the quartz, its pleochroism is green to brown."

Considering this description, we may establish the following points:

1. The rocks have the same mineral composition.

2. Texturally, they agree closely. Both are gneissic and show augen of quartz and feldspar, crushed rims, interpenetration of quartz and feldspar, undulatory extinction, etc.

3. Micro-perthite is present in both.

4. The hornblende shows the same pleochroism.

These points seem to bring out a strong similarity in the two rocks. We must remember, however, that this similarity may well exist in rocks of the same group which may come from widely separated localities.

These points of semblance are offset by the following contrasts:

1. Quartz is very abundant in the Harrison granodiorite where it forms as much as one half of the rock. In much of the Ravenswood rock, it is present in small amounts and in some cases is absent entirely.

2. The gneissic structure is present throughout the Harrison diorite, but it is lacking in much of the Ravenswood rock.

3. No muscovite was found in the latter.

4. Biotite is far more abundant in the former.

5. No augite was described from the Harrison occurrence, and no uralite was noticed.

Considering both of the above groups of points, it seems to the writer that the Ravenswood is not a continuation of the Harrison granodiorite. He believes that there are two distinct igneous bodies, of which one, the Harrison, has been the more thoroughly metamorphosed.

Petrographic Laboratory, Columbia University.

PLATE I

PHOTOMICROGRAPHS OF RAVENSWOOD GRANODIORITE

FIG. 1. Alteration of augite (A) into uralite (Hb). Biotite (B) and feldspar (F). Field, 1.7 mm.

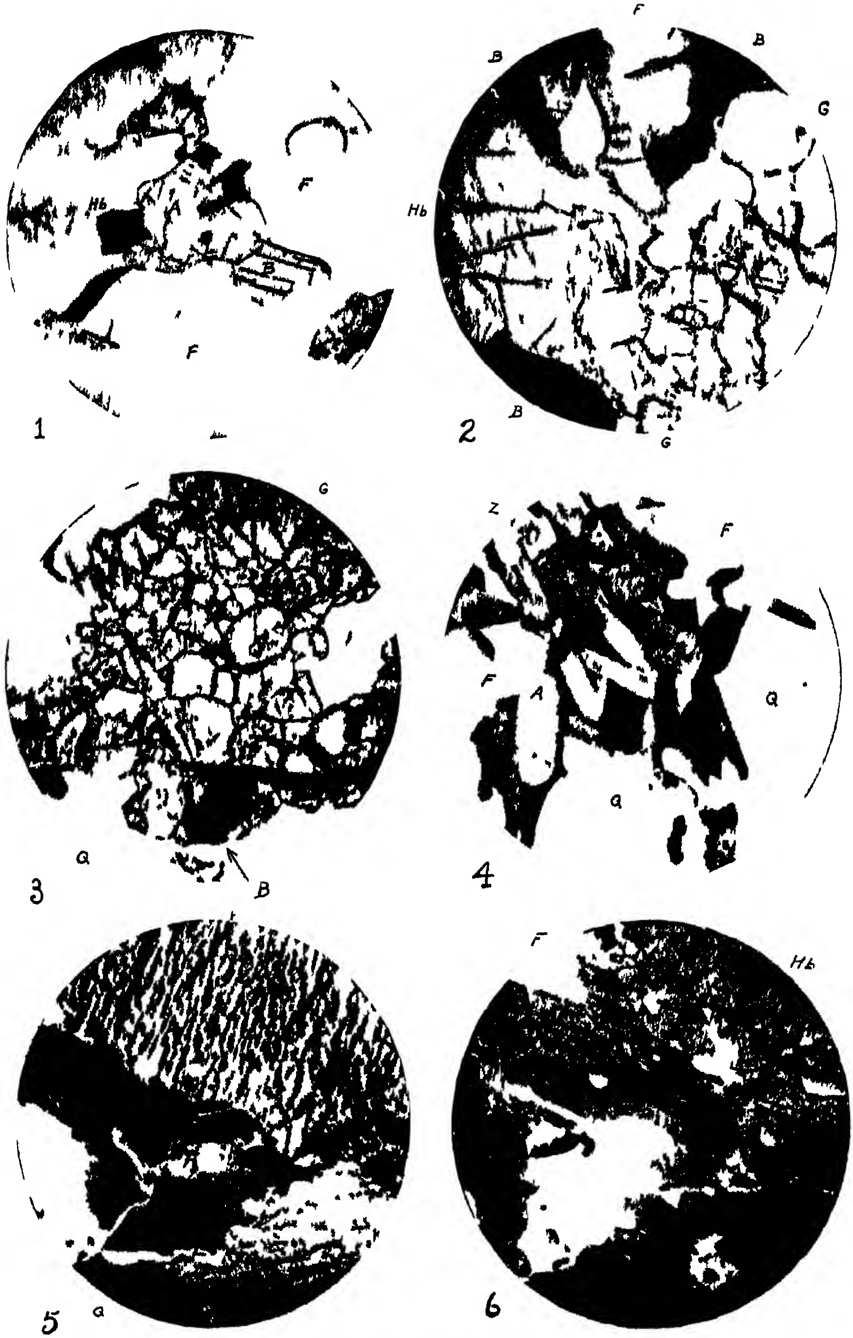
FIG. 2. Shows the relation of biotite (B), hornblende (Hb), garnet (G) and feldspar (F). Field, 1.7 mm.

FIG. 3. The garnet phase. Garnet (G), biotite (B) and quartz (Q). Field, 1.7 mm.

FIG. 4. Nest of biotite laths (B), with feldspar (F), quartz (Q), apatite (A) and zircon (Z). Field, 1.7 mm.

FIG. 5. Microperthitic feldspar (F) and quartz (Q) between crossed nicols. Field, 1.7 mm.

FIG. 6. The diorite phase. Hornblende (Hb) and oligoclase (F). Field, 1.7 mm.

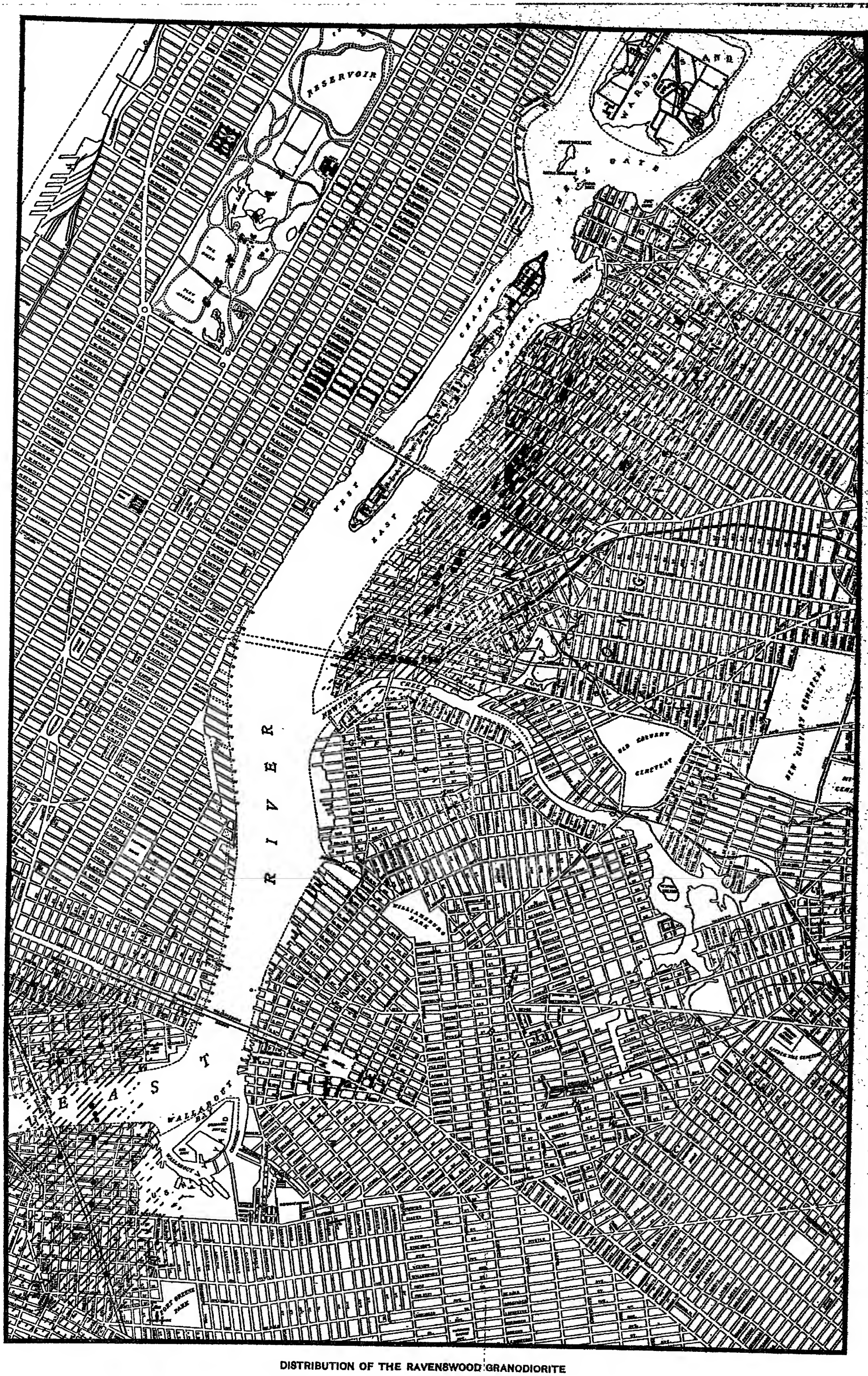


RAVENSWOOD GRANODIORITE

PLATE II

DISTRIBUTION OF THE RAVENSWOOD GRANODIORITE

Map showing the outcrops of the Ravenswood granodiorite in solid black; the boreholes reaching it, in black circular spots, and its probable extent, in broken lines.



DISTRIBUTION OF THE RAVENSWOOD GRANODIORITE

[ANNALS N. Y. ACAD. SCI., Vol. XXI, pp. 11–86, Pll. III–VI. 15 May, 1911]

GEOLOGY OF THE CORTLANDT SERIES AND ITS EMERY DEPOSITS [1]

By G. SHERBURNE ROGERS

(Presented in abstract before the Academy, 6 March, 1911)

CONTENTS

INTRODUCTION

The Cortlandt Series is a small but remarkably complete igneous complex, lying to the south and east of Peekskill, N. Y., or about 35 miles north of New York City. It was so named by James D. Dana, the first geologist to bestow upon it any particular attention, because of the approximate coincidence of its boundaries with those of the township of Cortlandt, the most northwesterly in Westchester County. More careful work upon its extent emphasizes the roughness of its conformation with

[1] The writer desires to acknowledge his obligation to Prof. J. F. Kemp, who suggested the subject of this investigation and under whose general direction it was carried out. To Prof. C. P. Berkey, the thanks of the writer are due for valuable advice and many suggestions generously imparted in the course of the work; and to Dr. M. A. Lamme for assistance and advice in connection with some of the chemical problems encountered.

the limits of the township, but the work of Dana and the later and more detailed investigations of George H. Williams have served to give the series a rather wide repute under this name. This area is between 25 and 30 square miles in extent, as will be seen from the map. The same rocks are found also in a small patch, less than a quarter of a square mile, on Stony Point, on the west side of the Hudson opposite the main development; these have been rather carefully mapped by Dana.[a] James F. Kemp has also described an extension of the series at Rosetown, N. J., where several of the types have been found; and Wm. H. Hobbs has discovered two large and well developed patches in western Connecticut. The present paper will be confined to the type development of the series around Peekskill, which exhibits the greatest complexity of differentiation.

The Cortlandt Series has hitherto, according to Williams's description, been thought of as a confused aggregate of basic rocks, in which the norite type predominated. As a matter of fact, although the norites are the most prominent type, examples of nearly every group from pegmatite to peridotite have been found, with local developments of very peculiar and abnormal rocks. It is thus much more complete than was formerly supposed and would merit a thorough study from the standpoint of magmatic differentiation. The rocks never show a distinct gneissoid structure; they are massive and unsheared, although there are several exceptions to this which will be considered later. The series is surrounded on every side by the Manhattan schist, inclusions of which are sometimes found in it but which are easily distinguishable on account of their schistose structure. Inwood limestone, underlying the schist, outcrops along the river bank from Verplanck Point north to Lent's Cove, and the inclusions of limestone are also found in the igneous rock, but the main areas are usually separated from them by the schist. Still other basic gneissoid inclusions are found which resemble the gneisses of the Highlands to the north. The whole Cortlandt Series, therefore, is a very complex and intricate mass and presents a petrographical problem of rare interest.

There is no lack of outcrops in the district, but it is seldom that the rocks can be distinguished in the field; all of them except the granites are dark pink or gray, and while the writer after some practice became able to identify typical specimens, the microscope could alone be relied on. It was deemed wise, therefore, to conduct the field work in a somewhat unusually careful manner; from 25 to 30 specimens to the square mile were collected in the areal work alone, and ten of these on the average were sectioned. Notwithstanding this care, there is, of course, consid-

[a] Am. Jour. Sci., (3), XXII, 112. 1881.

erable room for error; and it is to be understood that the various boundaries are probably not always exactly where they are drawn on the map, although never far away.

The massive character of the rocks precludes any topographic structures of particular interest. The weathering of the rocks is like that in all other such regions; in the case of the olivine rocks alone is there anything worthy of mention, and this will be taken up under their description (Plate III, Fig. 1). The most striking valley in the district is that in which lies the long curved tongue of schist, projecting north into the series; it is due, however, to a line of weakness along the contact and not to the igneous rocks themselves. In like manner, Lake Meahach, a stagnant inlet, seems to occupy a similar, though much less pronounced depression. Aside from these instances, the region is a succession of apparently irregular hills and valleys, becoming to the east rather wild and beautiful in a small way.

Historical Review

Considerable work has been done on this small district, and the evolution of our present ideas concerning it is interesting. Each of the earlier workers expresses a different view, which have been regarded since Williams's work as antiquated; yet it seems that some of these theories are not entirely to be cast aside, after all.

It is a very curious and interesting fact that the emery in this district was first seen and recognized by the first white man to ascend the river. The following passage is taken from Henry Hudson's report:[3] "The Mountaynes looke as if some Metall or Minerall were in them. For the Trees that grow on them were all blasted, and some of them barren with few or no Trees on them. The people [Indians] brought a stone aboord like to Emery (a stone vsed by Glasiers to cut Glasse) it would cut Iron or Steele: Yet being bruised small, and water put to it, it made a colour like blacke Lead glistering: It is also good for Painters Colours. At three of the clocke they departed, and we rode still all night." This transaction took place on his voyage down the river; and we read further that he descended eighteen leagues below this and was driven by the Indians to the shelter of a "Cliffe, that looked of the colour of a white greene." This was opposite Manhattan Island about two leagues below what is probably Fort Washington Point; it was probably, therefore, the Castle Point (Hoboken) serpentine. This would show that the emery was brought

[3] "The third voyage of Master Henry Hudson," New York Historical Society Collections, (1), I, 143. 1809.

aboard about 54 miles (by the river route) north of this, or possibly a few miles north of Peekskill.

W. W. Mather,[4] in 1843, described the rocks not as a series but merely under the lithologic types of Westchester and Putnam Counties. Under the caption "Sienite," he states that this rock forms the east bank of the Hudson River below Peekskill and is found in many of the hills southeast of Peekskill. It is valuable and a durable building stone, although rather hard to dress. It changes east of Verplanck to a black hornblende rock, which may contain iron. Pits have been sunk for coal in this rock but of course without success. Under "hornblende rocks," he merely mentions the dikes and stringers in the limestone at Verplanck. He evidently considers the rocks adventitious occurrences of a syenitic type, making no mention of the hypersthene, olivine, etc. and no suggestions as to their origin.

Herman Credner,[5] in 1865, made the earliest identification of the hypersthene which exists in many of these rocks. After describing it briefly, he states that there is a gradual transition of the hypersthene rock into syenite and hornblende schist. His work, however, was hasty and cursory and unsupplemented by the microscope; and, since syenite is rare in the district and hornblende schist unknown, his conclusions may be disregarded.

James D. Dana, in 1880, described these rocks in connection with his work on the limestone belts of Westchester County, being the first geologist to recognize them as genetically related and to study them as a whole. In his first paper,[6] he describes the rocks, classifying them as chrysolitic and non-chrysolitic, and subdividing further into hornblendic, hypersthenic, augitic and biotitic rocks. He then discusses their origin. Since they occur on Verplanck Point as dikes and stringers in the limestone and schist, showing contact effects, he is led to believe that at one time they had been molten, or at least plastic. From the considerable number of schist and limestone inclusions in the western part of the district, which generally lie approximately conformable to the strike of the main surrounding areas of these rocks, he concludes that the Cortlandt Series is a mass of old sediment, worked over by pressure and great heat; these inclusions would then be merely cases of unobliterated bedding. He finally discusses the very sudden minor variations in the igneous rocks (which are most frequent on Montrose Point) and believes that these also demand

[4] Geology of New York, pt. I, Geology of the First District, p. 528. 1843.

[5] "Geognostische Skizze der Umgegend von New York," Zeit. der deut. geol. Gesellschaft, XVII, 390. 1865.

[6] Amer. Jour. Sci., (3), XX, 194. 1880.

this explanation, arguing that sediment may change suddenly in composition but that igneous flows are constant over large areas. For the source of the heat, he postulates extreme local metamorphism of some kind.

In his second paper,[7] he reviews the above arguments and proceeds to the question of the origin and nature of the sediments. The rocks are so very different in composition from the surrounding sedimentary rocks that some peculiar local development must be postulated. There are three hypotheses: (1) the material may have been contributed by the Archean Highlands as detritus, or (2) as detritus supplemented by ingredients from the ocean, or (3) it may have been originally volcanic ashes. While expressing no definite opinion, Dana appears to favor the last theory, since successive outbursts might be very different in composition and yet come to rest in close juxtaposition. He suggests that the volcanic source lay in the present bed of the Hudson, between Verplanck and Montrose Points.

In his third paper,[8] he describes the phenomena exposed by the (then) new railroad cut through Stony Point, which he considers entirely indicative of the true igneous nature of the more basic members of the series at least. He abandons, of course, all of the above theories; and this affords an excellent example of the frankness, honesty and sincerity which characterizes his life and work.

George H. Williams, at about this time, started a minute petrographic study of the various types in the district, Dana having called his attention to the wealth of variation exhibited. He did not, however, publish his first paper until 1886.[9] After reviewing Dana's work, he announces his intention of describing the types petrographically, beginning with the most basic; then the contact metamorphism in the schist around the borders; and finally of giving his theoretical conclusions and generalizations. Starting with peridotite, he describes hornblende peridotite, devoting considerable time to the schiller structure so often found in all the rocks of the series, and then augite peridotite (picrite), giving an analysis of the latter. He takes up each mineral, discussing its general habit and its special peculiarities in these rocks, and often drawing valuable and scholarly comparisons with its occurrences abroad.

His second paper[10] is on the norites, which, he says, are by far the most abundant type in the district and cover the whole township east of the

[7] "Origin of the Rocks of the Cortlandt Series," Amer. Jour. Sci., (3), XXII, 103. 1881.

[8] "Note on the Cortlandt and Stony Point Hornblendic and Augitic Rock," Amer. Jour. Sci., (3), XXVIII, 384. 1884.

[9] "Peridotites of the Cortlandt Series," Amer. Jour. Sci., (3), XXXI, 26. 1886.

[10] "Norites of the Cortlandt Series," Amer. Jour. Sci., (3), XXXIII, 135, 191. 1887.

railroad. A glance at the map suffices to show the incompleteness of his knowledge as regards the distribution. He discusses first norite proper; then hornblende norite, mica norite, augite norite and finally pyroxenite. Under mica norite, he describes the "Butler Section," a cliff in which norite proper, augite norite and other rocks are arranged in layers. He ascribes it to ordinary metamorphism. This and similar cases have been described by the present writer[11] and will be discussed in the paper here contributed. Williams states also in this paper that the emery is a segregation in the norite and discusses in this connection the composition of the ore as compared with that of Ronsperg, Bohemia. In a later note,[12] he gives an analysis of the orthoclase of these rocks, which removes the suspicion that it may be merely unstriated plagioclase.

Williams's third paper[13] is on the gabbros and diorites. He states that the gabbro is a rather rare rock; but adds that it always shows metamorphism and always occurs adjoining the limestone, therefrom deducing the fact that it is a hybrid formed by the action of the norite magma on this latter rock. He divides the diorites into hornblende and mica diorite. Under the caption hornblende diorite, he describes in turn brown hornblende diorite, hornblendite, green hornblende diorite and mica hornblende diorite. He subdivides mica diorite into mica diorite proper, hornblende mica diorite, hypersthene mica diorite and quartz mica diorite. In concluding, he states that the series is due to long-continued igneous action, different types being successively produced which broke through those already solidified, the more acid types apparently appearing last.

This concludes his petrographic study, and notwithstanding the incompleteness of his knowledge of the distribution and extent of the types, his work stands as a well-rounded and scholarly investigation. His nomenclature is particularly felicitous; in a district of such multifarious differentiations, the free use of mineral prefixes is preferable to the adoption of a number of new terms. It is greatly to be regretted that Professor Williams's untimely death prevented the further prosecution of his work in the district; a complete study of the magmatic differentiation in the Cortlandt Series would have been indeed valuable from a petrologist of his experience and perspicacity.

Consonant with his original plan, having completed his study of the igneous rocks themselves, he describes their effect on the surrounding

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[11] "Original Gneissoid Structure in the Cortlandt Series," Amer. Jour. Sci., (4), XXXI, 125. 1911.

[12] *Op. cit.*, p. 243.

[13] "Gabbros and Diorites of the Cortlandt Series," Amer. Jour. Sci., (3), XXXV, 438. 1888.

rocks.[14] He here states that the emery may be referred with certainty to contact action on pre-existent material, apparently abandoning his former view. In studying the other contact effects, he concentrated on several linear sections, in the first two of which he describes the succession from ordinary mica schist to the same rock carrying sillimanite, then to a rock composed of sillimanite, mica and garnet, and finally to a garnetiferous mica diorite. Analyses show that the change in the schist is in the direction of an increased alumina and iron content as the massive rocks are approached. In the last section of the massive rocks on the limestone, he finds that lime-bearing hornblende and pyroxene are formed along the contact. He finally compares the effects here with those in several European localities, showing that a larger number of contact minerals is found in the Cortlandt than anywhere else. The contact effects were thus shown to be well developed, a point which will be reverted to in the discussion of the genesis of the emery.

James F. Kemp,[15] in 1888, described the Rosetown extension of the series; he had also been over the main area under the guidance of Professor Williams. This smaller body lies about a mile west of Stony Point and is itself about three quarters of a square mile in extent. It is surrounded by gneiss and encloses a small patch of marble. The rocks themselves are all diorites, no hypersthene or olivine having been found in them. Green augite occasionally assumes importance, but in the main it is subordinate to the brown and green hornblende. Emery, similar to that found in the main area, occurs in these rocks. There is very noticeable contact action along the borders, and numerous dikes radiate out into the surrounding rocks. Six analyses are given in connection with the petrographic description, three of the rocks and three of isolated minerals.

William H. Hobbs[16] has described the Connecticut extensions of the series in an article which unfortunately is not particularly well known. Two areas were found by him in the crystalline upland of western Connecticut, which resemble the original Cortlandt area both in the abundance of norites and in the elaborate magmatic differentiation; these constitute the northeasterly extension of the Cortlandt.

The Prospect Hill area, which is the larger and more important of the two, covers about 40 square miles in the township of Litchfield, although

[14] "Contact Metamorphism produced in the adjoining Mica Schist and Limestone by the Rocks of the Cortlandt Series," Amer. Jour. Sci., (3), XXXVI, 254. 1888.

[15] "On the Rosetown Extension of the Cortlandt Series," Amer. Jour. Sci., (3), XXXVI, 247. 1888.

[16] Festschrift zum siebzigsten Geburtstage von Harry Rosenbusch, p. 25, Stuttgart. 1906.

most of the types are found in a small patch about two miles square at Prospect Hill itself. The igneous rocks are included in highly metamorphosed gneiss, quartzite and schist of pre-Cambrian and early Paleozoic age, so that they are probably post-Ordovician. Along the border, there is generally a mosaic of block faults. The rocks may carry considerable percentages of pyrrhotite and chalcopyrite, which are exploited in many prospect holes known locally as "nickel mines." Hobbs describes the rocks as varieties of the following types: gabbroitic, noritic, olivine-hypersthene gabbroitic, dioritic, peridotitic, pyroxenitic and grano-dioritic. Although his system of nomenclature differs somewhat from that followed in the present paper, it seems that all of these types are counterparts of those found in the main area. The most salient points of difference are the abundance of somewhat more basic plagioclase and of chalcopyrite and pyrrhotite, with the absence of emery, in the Connecticut areas. Five complete and valuable analyses are given, and the differentiation is very suggestively summarized in a series of Brögger diagrams. In the smaller, New Fairfield, area, the rocks are all of a dioritic nature, resembling in this respect the Rosetown, N. J., extension.

From the description given, it is evident that the larger area at least would warrant close study; it is to be regretted that the boundaries of the main districts, and the approximate distribution of the many interesting types described, have not been more thoroughly worked out.

Charles P. Berkey,[17] in connection with an exhaustive study of the geology of the Highlands and the region to the south, has materially added to our knowledge of the Cortlandt Series. He has been the first geologist to map the boundaries; the writer has, of course, gone over the same ground in connection with this present study, and the results are entirely concordant. To Dr. Berkey also belongs the credit for the recognition of the acid extreme of the series; the large granite area to the northeast of the main body was overlooked by both Dana and Williams. As will be shown later, there is every reason for considering this an integral part of the series; and if this be so, it completes the line of differentiation from the most acid to the most basic, being thus an important consideration from a theoretical standpoint. The writer is under great obligation to Dr. Berkey for this as yet unpublished information.

This, then, constitutes the whole of the work done on the Cortlandt Series. As will be seen, some of it has been superficial, some ill-directed and some disproportionately minute. Kemp's work on the Rosetown

[17] "Structural and stratigraphic features of the basal gneisses of the Highlands," Bull. N. Y. State Museum, 107 (Geology 12). 1907. This paper is the first in connection with this study and is not concerned with the Cortlandt Series

extension is complete in itself, as is that of Hobbs on the Connecticut areas; but as for the main area, the most recent work done on it—that of Berkey on the boundaries—is what should have been the earliest. Owing to this somewhat unfortunate reversal, there are several erroneous conceptions extant concerning the series; and the writer, while not pretending to the experience of Dana or the erudition of Williams, hopes in the following pages to give a correct general notion of the rocks as a whole, leaving to later investigators that part of the more specialized work which is yet undone.

Correlation

The correlation of the series is, like that of many such igneous masses, open to considerable speculation. Evidence of its age with respect to the surrounding rocks is indubitable; in a number of places, marked contact action is shown, and on Verplanck's Point especially a number of igneous dikes are intruded into the schist and limestone, so that the Cortlandt series is unquestionably younger. The lower limit, then, is dependent on the age of the Manhattan schist and the associated Inwood limestone.

There is, however, considerable difference of opinion as regards the correlation of these rocks. A. C. Spencer[18] and his associates regard them as the metamorphosed equivalents of the Cambrian and Ordovician, which occur in an unaltered condition north of the Highlands. C. P. Berkey,[19] on the other hand, who has been mapping the Tarrytown and West Point Quadrangles in the Highlands of New York, finds that the Manhattan schist and Inwood limestone are separated by unconformities from both the basement gneiss series below and the Poughquag quartzite above, this latter representing the base of the Paleozoic. The schist and limestone are therefore pre-Cambrian.

The Cortlandt Series has been intruded into these rocks and is therefore at least later than pre-Cambrian time. Moreover, since the schist and limestone were strongly metamorphosed, probably in the Green Mountain upheaval, the series must be post-Ordovician. There is no criterion, however, by which we can fix the upper limit. Van Hise and Leith[20] make the following rather cryptic remark: "The rocks of the Cortlandt Series (the clastics) of the original Taconic area and of the upper series of the Adirondacks are of the same age, *i. e.*, Taconic, or Lower Cam-

[18] A. C. Spencer summarizes his own work and that of W. S. Bayley in New Jersey, and the work of E. C. Eckel and F. J. H. Merrill in New York, in Bulletin 360, U. S. G. S., "Precambrian Geology of North America," by Van Hise and Leith, p. 634. 1909.
[19] *Op. cit.*, pp. 361-378.
[20] *Op. cit.*, p. 319.

brian." The writer is not aware of any clastics in the Cortlandt Series, nor does there seem to be any justification for calling the series Lower Cambrian. There is a general lithologic similarity with the upper series of the Adirondacks, but the almost entire absence of metamorphism in the Cortlandt Series, coupled with the surprising freshness of the olivine present, are rather strong indications of a considerably later date. The Triassic trap of New Jersey is so entirely different in structure that the Cortlandt Series has probably no relationship with it; and from the lithologic character of later igneous masses and from the fact that no metamorphism has taken place in the East since the Permian, it is practically certain that the series is not post-Permian. Kemp's study of the Rosetown extension fully confirms this view; he finds[21] that the rocks here cut the (Cambrian) Tompkin's Cove limestone but have not disturbed the Triassic sandstones. Hobbs's work in Connecticut is also entirely concordant. The whole expanse of the Paleozoic is, however, open; and while nothing can be definitely said, it is the writer's opinion that the Cortlandt Series is younger than is generally supposed, more probably late Paleozoic than early Cambrian.

Petrology

In the following descriptions of the various types, the rocks will be considered in the order of their acidity, and frequent reference will be made to the large geological map. In the case of the common rock minerals, at least, an effort has been made to condense as far as possible the mass of data which has accumulated from the description of the 260 slides examined and to render the optical descriptions reasonably brief and succinct. In every case, the fullest description of the various minerals is given under the important rocks in which they are the most abundant or of which they are the most typical. Williams, in the papers cited above, has sometimes given fuller and more minute optical discussions of the minerals than is here considered necessary.

PLUTONIC ROCKS

Granite

The granite member of the series lies to the northeast of the main body and extends from south of the Crompond Road northward to Lake Mohegan. It covers an area of about $3\frac{2}{3}$ miles, and throughout its extent it appears to be very uniform in texture and composition. The exact bor-

[21] *Op. cit.*, p. 253.

ders of the area are not, however, susceptible of close determination; a heavy blanket of drift covers the district and obscures the geology. Outcrops are few and are generally considerably altered, except when the rock is artificially exposed. The land surface is on the whole rather flat for a rock of this character, as compared to the hilly topography southward; this may be due to the fact that it lies in the lee of the Highlands, which would cause an undue accumulation of till at this point, fading away to the south. The granite is surrounded in general by mica schist, but to the northwest lies an area of pinkish granitic gneiss, related to the typical Highland gneisses.

As stated above, the credit for the recognition of this rock as part of the Cortlandt series belongs to Dr. Berkey. He has as yet published only a short note on the subject.[22] Dana does not mention this area at all; and since he apparently guided Williams over the country, the latter likewise overlooked it. Closer work on the geology, however, reveals its unmistakable relationship with the neighboring basic rocks. Its entire lack of (megascopic) metamorphism separates it sharply from the surrounding schists and gneisses and places its age as approximately the same as that of the rocks to the south. It has undergone about the same degree of weathering as have the basic rocks. Furthermore the latter are frequently penetrated by aplite and pegmatite dikes, which are closely akin to the granite; these are especially abundant in the northern part of the basic area. There are, however, apparently no areas of granite in the latter district; the acidic flow seems to have been more sharply separated than the various intermediate and basic facies of the magma. The penetration of the basic rocks by the acidic dikes would seem to indicate that the acid extreme of the series is the youngest; the chronological and chemical relations of the various members will, however, be more fully discussed at the end of the petrographical descriptions.

In the hand specimen, the granite is practically white when fresh, being made up almost entirely of quartz and feldspar, with very subordinate amounts of muscovite and biotite. The rock is generally weathered at the surface to a faint dirty brownish color, owing to the formation of epidote. The grain is medium, and the rock is very firm. A number of specimens were taken from the surface outcrops; several from the quarries, and one from a diamond drill boring at the 200 ft. level. The thin sections show that the rock is remarkably uniform in composition. Quartz, in large angular grains, constitutes in general about one-half the rock. It shows numerous rehealed cracks but few inclusions. The feld-

[22] "The acid extreme of the Cortlandt Series," Science, XXVIII, 575. 1908.

spar, which makes up perhaps two fifths, is generally orthoclase, with varying amounts of microcline and plagioclase. The extinction angles of the latter show it to be albite and oligoclase. In all of the sections examined, the feldspar was considerably altered to kaolin, this being much more striking than in the other members of the series. Epidote also occasionally forms in small amount through the feldspar. In the four thin sections of granite from the quarries, the alteration of the plagioclase was especially apparent, as was also the case in the rock from the drill core; in the surface specimens, however, the orthoclase seems to be the more kaolinized. Several cases of zonal alteration in orthoclase were noticed. Muscovite occurs in typical habit; the grains vary considerably in size but are seldom as large as the quartzes. It is altered only in the surface specimens; in these, it is hydrated and appears to yield damourite. It is usually much more abundant than the biotite. The latter is seldom entirely fresh and is often altered to chlorite. Hornblende is rare, and when found is generally altered. Magnetite is present in very small quantity; apatite and zircon are practically lacking.

In the diamond drill hole above referred to, which was sunk to 425 feet for water at a point half a mile east of Jacob's Hill, the ordinary white granite was first encountered; this changed gradually to a somewhat finer grained bluish gray-white granite carrying a larger perçentage of quartz. Through this, several streaks of a basic hornblendic segregation, a foot or so across, were found.

At several points, the granite is quarried as a building stone. The three cuts to the northeast are known as the Mohegan Quarry, the one to the south as the Peekskill or Cornell. The latter is the largest; from it was taken the rock out of which the bulk of the Cornell Dam across the Croton River was constructed. The granite from the Mohegan quarry is used as the chief building stone in the Cathedral of St. John the Divine, in New York City, which when completed will be the fourth church in size in the world. The stone has also been employed in several other edifices in the city. While the alteration of the granite is considerable, as above described, it is not serious in character; and the rock commends itself on account of the paucity of the dark minerals. The alteration of the small amount of biotite has proceeded as far as it is likely to; the muscovite and orthoclase are fairly stable minerals; and the plagioclase is not abundant, while the large amount of quartz insures the rock against serious alteration. Pyrite and other notably deleterious constituents are entirely lacking. The rock is firm and easily worked, although the abundance of joints of all sizes militates against the extraction of large blocks. The actual amount of granite taken out varies,

of course, with the demand, but it probably greatly exceeds in value the emery mined to the south.

Syenite.

Syenite constitutes a member whose areal importance is small and whose existence even is not well defined. Three small patches were found, two on the borders and one in the interior of the district. The patch to the north lies between biotite norite and Manhattan schist, as does also the small area on the southern border; the interior patch is surrounded by hornblende norite.

In all of these areas, the rock is heavy and dark gray, appearing much more basic than is actually the case. The rock in the northern patch is very fine grained and micaceous (biotitic), although the mica has no regular orientation. Some of the feldspar is evidently glassy oligoclase, while much of it is faintly pinkish. The thin section confirms these observations; the feldspar is about half oligoclase, slightly kaolinized, and half orthoclase in larger and more irregular grains, somewhat more altered than the triclinic feldspar. Slight recrystallization and wavy extinction are apparent. Several small grains of quartz, giving unmistakable interference figures, and evidently original, are present. Biotite, typically developed, is practically the only dark mineral to be seen; green augite is present in very small quantity. Apatite is abundant in fairly large crystals, and ilmenite is present in small grains.

In the southern patch, the rock is also fine grained, gray and micaceous. The specimen sectioned was taken from a small quarry at the juncture of the two roads and looks entirely fresh. In thin section, it resembles the rock described above, except that the orthoclase is much more abundant and that there is more quartz. The triclinic feldspar is oligoclase, as above. There is also a moderate amount of deep green hornblende and a little pyrite. The amount of alteration, however, is surprising: the feldspar is somewhat sericitized, and there is a moderate amount of chlorite and epidote and considerable calcite in small irregular patches. This rock is evidently much like the rest, although it is a more typical syenite.

In the interior patch, the rock is similar to the other megascopically, except that there is less biotite. In thin section, it appears that the orthoclase is predominant over the oligoclase but that what quartz there is is secondary. Hornblende is the chief ferromagnesian mineral, but alteration to scaly chlorite, starting from the center of the crystal, is very common. The biotite is typical but somewhat altered and is usually found clustering around the hornblende laths. Pyrrhotite is present in small quantity and magnetite, ilmenite and apatite in moderate amount.

The syenites are thus a fairly well distinguished group, although that of the northern area is related to the gabbros and that of the interior is almost a monzonite. It differs from them chiefly in the prominence of the orthoclase and in the considerable amount of apatite, this mineral being present in very small quantity in the typical Cortlandt monzonitic diorites. There is little of interest about this area, but the location of the other two between mica schist and biotite norite is very suggestive, taking into account the similarity between these two widely separated areas. A discussion of the possibilities of contact action must be reserved for another portion of this paper, but it may be noted here that if it be possible for the molten norite magma to act upon the mica schist to form a rock of normal igneous composition, this third rock would probably be approximately syenitic, both in chemistry and in mineralogy. No analysis of the syenite was made; but the analyses of biotite norite and of mica schist, given below,[23] may be compared. Williams[24] suggested the same idea with reference to the gabbros, supposing that they always appeared between limestone and norite. His premises are not altogether correct, but the general idea can scarcely escape one who has worked on these rocks.

Sodalite Syenite

Sodalite syenite was found in only one place, and then in a very small place. It is interesting chiefly from a theoretical standpoint, as the only representative in the series of the feldspathoid group. Its field relations are somewhat peculiar. It is located at the north end of the road, immediately east of Lake Meahach, on the contact with the inclusion of quartz schist found at that place. Starting from the south, we have the sodalite syenite (whose exact extent is indeterminable, but probably small), then the schist, then a light colored augite monzonite in a strip about five feet across, following by schist again. This is cut about 20 feet farther by a much altered minette dike, three feet wide; beyond this the rock is largely covered, and the exact contact of the schist on the north is hidden. It is thus impossible to say whether the sodalite syenite is a thin contact strip surrounding the schist or not, although it is certain that it does occur on the southern border. The significance of the augite monzonite is difficult to perceive; it is not a dike and is therefore probably a tongue of the country igneous rock projecting into the schist and partly altered by it.

[23] See pages 61 and 65.

[24] Amer. Jour. Sci., (3), XXXV, 440. 1888.

The sodalite syenite is a very fine grained black rock, in which biotite is the only mineral visible. It is somewhat brecciated and is considerably altered. Under the microscope, the biotite is seen to be subordinate in amount to a green hornblende, the crystals of which are often dislocated across the cleavage, leaving cracks filled with an isotropic substance. There is little orthoclase, moderately altered, and no plagioclase. The sodalite is fairly abundant, and is typically developed, in rounded isotropic grains, $n < 1.54$. It has none of the structures of analcite, and the latter moreover could hardly form in so acid a rock and one in which the orthoclase is so slightly altered. Somewhat more abundant than the sodalite is a mineral which seems difficult of identification. It occurs in grains which are often hexagonal, having a relief of about 1.54 and a medium (second order) birefringence. It is biaxial positive. Its hexagonal outline would suggest some derivative of nephelite, which would be expected in this association, but it is not cancrinite or any of the other common alteration products. Thomsonite usually occurs in a more fibrous form, although except for this, the characters correspond rather closely. The exact determination of this mineral, however, would hardly affect the name given the rock, which stands as another suggestive occurrence of a zone on the border of the mica schist.

Diorite

The diorites are more important in the western part of the district, where they cover an area of about two miles. Since Dana and Williams worked chiefly in this section, the diorites appeared more important to them than they really are, for, except for this area, they appear only as small isolated patches. There is one at Pleasantside and another about half a mile southeast of that place; three along the southern border of the series, and a confused mass on Montrose Point. On Stony Point, across the river, they are found. There is also a garnetiferous phase a mile and a half east of Pleasantside associated with the emery; and diorites, often very micaceous, constitute the immediate wall rock in several of the emery cuttings on the hill just east-northeast of that village.

As stated above, Williams subdivides the diorites entirely on the basis of their dark minerals, arriving thereby at brown and green hornblende diorites, mica-hornblende diorite and mica diorite. He states in this connection that the brown hornblende diorites tend to pass into norites and pyroxenites, while those with green hornblende show aspecial affinity for the mica-bearing rocks. These observations are quite correct; there is every gradation from a diorite whose sole ferromagnesian mineral

is green hornblende, to one which carried biotite alone, and in the field, moreover, the two types are very intimately related. The whole of the large area of diorite is of this type, except in two places along the contact of the diorites with the pyroxenites, where the hornblende is brown, the rock carrying biotite as usual. All of the smaller areas of diorite carry green hornblende excepting two,—the patch just southeast of Pleasantside, which appears to grade into the associated hornblende norite, and the northern part of the area southeast of Salt Hill, which appears to be closely associated with the neighboring biotite augite norite, both carry the brownish variety. This latter patch, however, shows green hornblende along its southern margin. Williams's conception of the affinities of these two main types, derived from the study of a small portion of the district, appears to hold therefore for the whole series.

On Montrose Point, the brown hornblende is most plentiful, both in the hornblende pyroxenites shown on the map and in associated diorites which are not mapped. The extraordinary complexity of the rocks on Montrose Point makes the geology impossible of adequate representation, and it was deemed advisable, therefore, to map merely the most abundant rock, the pyroxenites. To quote from Williams:[25] "These rocks (hornblendites) have a glistering black color and are most intimately associated with the norites, hyperites, diorites and pyroxenites which also occur there. No more complicated interpenetration of eruptive rock-types could possibly be imagined than is displayed at this locality—every rock includes and forms dikes in every other; and at the same time, every type passes by gradual changes in its mineralogical composition into every other one." It is here, then, that the brown hornblende is best developed; and in this wonderfully complicated net-work of rocks, it grades on the one hand into a biotite augite norite and on the other into hornblendite and hornblende pyroxenite. In the latter rock, it is especially well developed and often approaches basaltic hornblende in color, birefringence and relief.

An attempt was made by the writer to classify the diorites on the basis of their feldspar, into monzonites and diorites. In most of the diorites, the unstriated feldspar constitutes from one third to two thirds of the whole. Williams states that on a number of tests made on the feldspar, however, the specific gravity ran from 2.648 to 2.67, which would show it to be plagioclase of the oligoclase-andesine series. Moreover, the recasting of the subjoined analysis of diorite shows that all of the potash must be in the biotite, although the rock would be called a monzonite,

[25] Amer. Jour. Sci., (3), XXXV, 441. 1888.

if all of the unstriated feldspar were considered orthoclase. The pericline twinning is usually, of course, very faint, and much of the ostensible orthoclase is probably plagioclase twinned according to this law. While this analysis shows an exceptionally low percentage of silica,[26] it indicates that the identification of the orthoclase must be attended with great care and that a subdivision by this criterion would be very hazardous. At the same time, microperthite was noticed in one slide and quartz in another, so that orthoclase is probably often present.

The diorites in the hand specimen vary greatly in appearance. They are generally of medium grain, although they vary from almost felsitic to an extremely coarse rock at Crugers in which the hornblendes are six inches long. The transitions in texture are very sudden, although there appears to be no concomitant change in composition. The feldspar is usually white, and the rock is then distinguishable in the field, but it is often a dark gray. The hornblendes are occasionally in slender laths, though usually in poorly defined grains.

The microscopic features have already been largely covered. The characteristics of the feldspar have been noted; the plagioclase varies from oligoclase to andesine, although it may be labradorite when the rock carries hypersthene. The hornblende is usually green with strong pleochroism: X olive green, Y brownish green, Z brownish yellow, though X may occasionally become bluish green. It is rarely in laths and never so when it is of the brown variety. The green variety especially often carries delicate parallel inclusions, presumably of ilmenite, which resembles somewhat the partings of diallage or enstatite. It alters to chlorite and epidote, and in one instance secondary biotite seemed to have been formed. The biotite is usually of a deep brown color, apparently high in iron and showing excellent pleochroism. It may be almost wanting and may again almost replace the hornblende. In basal section, it is nearly opaque. The optical angle is extremely small. It is usually associated closely with the hornblende, and they appear to have been crystallized simultaneously. Epidote, apparently original, was found in one slide as figured by Williams.[27] Quartz is rare but occasionally occurs in small grains. Magnetite and ilmenite, this last usually the more abundant, occur in ordinary quantity, and pyrite and pyrrhotite are not rare. Apatite, while sometimes abundant in large crystals, is usually notably less than in the norites. Garnets are abundant in the locality noted above.

[26] WILLIAMS (*Op. cit.*, p. 444) states that an average of four silica determinations was 58.94 per cent The particular rock analyzed by the writer is probably abnormally basic, although, under the microscope, it appeared quite typical.

[27] *Op. cit.*, p. 445.

The chief transition of the diorites is marked by the entrance of hypersthene and enstatite, which leads to the hornblende norites with the decrease of biotite and to gabbro and biotite augite norite, with the entrance of augite. The latter, however, is rare, and in only a few of the diorites was either of these minerals noticed. In one case, an approach to a diabasic texture was observed, but this reversal of the normal order is uncommon.

The alteration of the diorites is a very salient characteristic. Aside from the ordinary weathering to chlorite, kaolin and epidote, sericite was noticed in several specimens along the schist contact at the north end of Lake Meahach. In these rocks, moreover, and in those taken from similar positions, a very perceptible amount of strain was noticed. The feldspars showed pronounced mortar structure and wavy extinction, and the biotite was twisted and bent. The same phenomena are apparent in less development in most of the diorite slides examined; either because of their location, or on account of an inherent weakness in the rock itself, the metamorphism of this type is more evident than it is in the case of any other member of the series.

Gabbro

Gabbro is somewhat akin to the last mentioned type, but unlike the diorite it is areally unimportant. Only one important area was found, situated on the northern border just to the east of the syenite area there and lying between the biotite augite norite and the mica schist. Its position is thus analogous to that of the syenite, the accompanying norite here carrying augite, whereas that which adjoined the syenite carried merely biotite. Moreover, the syenite carries a small quantity of augite, which, with other characters emphasized below, would seem to indicate its close genetic relationship with this gabbro. The syenite and gabbro very possibly adjoin; but since no outcrops are available for a space of half a mile between them, it was deemed best to map them as found.

The rock of this area is dark gray and micaceous, closely resembling the syenite, although the short stout augites may be distinguished on close examination. The grain is medium fine and the rock quite fresh, although well jointed. In thin section, it appears that the plagioclase is a basic andesine, but that nearly a third of the feldspar is unstriated and in rounded irregular grains, indicating orthoclase. The biotite is abundant and characteristic, with pleochroism from golden yellow to brownish black. The augite is green, non-pleochroic, and shows extinction angles from 45° to 50°. In basal section, it shows cleavages at 89° and gives a good positive axial bar. Only one grain of hypersthene is visible. Apa-

tite is not very abundant. Several small grains of what seemed to be quartz were seen.

A small area of a very simple gabbro lies in the extreme southeastern corner of the district, where it is intimately associated with diorite and biotite augite norite. The gabbro phase is composed entirely of augite and feldspar. This rock, or more probably a mixture of the three, was used for the basement work of the Cornell Dam across the Croton River, but while the crushing strength was all that could be desired, the abundance of chloritized joints was found to affect seriously the value of the large blocks required, so that the engineers were finally forced to employ the granite described above. A large quarry, however, was opened, and most of it still remains above the level of the lake.

Another type of gabbro is found, however, which is very different. It occurs in two localities adjoining schist inclusions; one at the north end of Lake Meahach and the other just west of Montrose. In the field, it closely resembles limestone, being gray and homogeneous in appearance and weathering in layers. Under the microscope, it appears that the rock is made up chiefly of two minerals, feldspar and augite. The latter is brownish but is non-pleochroic and otherwise typical. Biotite, apatite, ilmenite and titanite are present in small amount.

The most extraordinary feature of the rock is the amount of shearing which it has undergone, which far exceeds anything noted elsewhere in the series. The augite is distributed in bands, in some of which the mineral is actually granulated, and these surround "augen" of broken augite and feldspar. This lenticular effect is visible in the specimen, especially when polished. The whole rock resembles a badly crushed gneiss, rather than any of the other members of the Cortlandt Series, and it may possibly represent one of the inclusions of Highland gneiss which are found elsewhere in the district. Since, however, it seems to be associated with the schist inclusion, it is probably a true igneous rock, from the strained and crushed zone which might be expected to border such a foreign mass, and movement of the latter just before the consolidation of the igneous rock may have contributed to this extraordinary crushing.

Norite

The norites are perhaps a trifle more abundant than any other group, although they do not, as Williams and Dana supposed, constitute the great bulk of the series. The general norite magma exhibits several facies, which are distinct rock types and which yet often pass into one another by insensible gradations. That the classification made upon a

petrographical basis is not academic is evidenced by the areal distribution—the various types fall naturally into distinct areas. Their general distribution is suggestive, for although occasional isolated patches occur, practically the whole of the norite magma, in its various ramifications, is confined to the central part of the Cortlandt area, being flanked on the west by diorites and pyroxenites and on the east by the latter. At the north and south, they are often separated from the mica schist by syenites, diorites and gabbro; and if the boundary could be accurately traced, it is very possible that these or similar rocks would be found continuously along the margin.

True norite, which is composed merely of hypersthene and feldspar, occupies a very peculiar position in the series. It does not appear on the map, since it never covers an appreciable area; it occurs always as inclusions in the other members of the norite family and generally, if not always, in those containing biotite. These inclusions are sometimes streaks and sometimes rounded flow-like patches, and this imparts a very peculiar appearance to the norites, especially in the northwestern corner of the area. The inclusions vary in size from a few inches to possibly forty or fifty feet across, though the smaller ones are the most common. Absolutely pure specimens are rare, inclusions in which augite and biotite appear in insignificant amount being the general thing. This pure norite is found frequently in the district between Spitzenberg Hill and Peekskill, especially along the post-road to the west; at Pleasantside again it is well developed, and striking cases were also found (see Plate IV, fig. 2) in the woods a mile south of Spitzenberg. It may occur anywhere in the biotite-bearing norites, however, and the above cases are merely a few examples.

The rock is easy to distinguish in the field, since it is always fine grained. Its color is usually pale pink, owing to the amount of plagioclase present, and scattered through this are the black hypersthenes. As the grain grows coarser, a little biotite and augite may enter, and the rock conceivably grades into the more complex and coarser norites.

Under the microscope, it appears that the pink color of the plagioclase is due to the presence of a fine reddish dust, which Williams has figured and discussed at some length.[28] Under a high power, this dust resolves itself into plates, rods and globulites, presumably of hematite. The plates may be hexagonal, rectangular or irregular, and they vary in size up to .01 by .04 mm. The rods are often arranged in rows, forming a kind of discontinuous needle, but these exhibit no parallelism to any

[28] Amer. Jour. Sci., (3), XXXIII, 141. 1887.

structure of the feldspar. The globulites are extremely small and are scattered promiscuously over the crystal, except at the border and on the margins of the larger inclusions (*i. e.*, the rods and plates, or crystals of magnetite); and this clear margin moreover varies directly as the size of the inclusion. This would indicate that they represent the form in which the iron of the rock first crystallized, many of them combining later to form the larger inclusions. The inclusions may be gray in color, then imparting a dark gray color to the feldspar, and they may be so plentiful that the mineral even in thin section is gray. They are described here at some length, because this reddish dust is very characteristic of the plagioclase in all of the norites and separates it sharply from that in the gabbros, diorites, syenites and granites. The feldspar in this rock is usually in a mosaic of small grains, the lamellæ of the plagioclase occasionally showing strain. The variety is usually andesine, as determined optically (angles 18°–20° on sections perpendicular to (010) and by specific gravity (2.674, according to Williams). The presence in considerable amount of orthoclase is attested by the analysis and by specific gravity determination, but the proportion varies greatly in different specimens. Carlsbad twinning and zonal growth have been noticed.

A description of the hypersthene had best be reserved, since in the pure norite it is not altogether typical. The pleochroism is generally somewhat fainter than usual, being from pink to light green. The crystals are usually small and arranged in clusters, and inclusions are few or wanting altogether. Magnetite and ilmenite are usually present in smaller amount than in the other norites. Apatite is fairly well developed. Williams also mentions garnet and pleonaste in specimens collected at an emery cutting, but these minerals are associates of the ore and are usually not found elsewhere. A peculiar variety of this rock, in which the hypersthene has a rather remarkable habit, is found only at the emery mines and will be described below.

Biotite Norite

Biotite norite is one of the three more important members of the norite family, covering perhaps three and one-quarter square miles. It occurs in two large areas and at least three small ones. In the area back of Montrose Point, a number of small emery pits have been opened. This patch may possibly be connected with the larger one to the east of the railroad. One of the other areas is in biotite augite norite in the south central part of the district and the other in pyroxenite in the extreme eastern end. It is thus always associated with the other norites, as stated

above, and shows particular relationship with the biotite augite variety. Williams records it from only one place (along the road to Montrose Point), which is so small an area that it cannot be mapped.

In the hand specimen, the biotite is, of course, distinguishable, but these rocks cannot be told from those which carry also augite. The feldspar often imparts a dark pink color to the rock, but it is as often a dark gray. The grain is medium, being never very fine or very coarse. A faint gneissoid structure is occasionally apparent, but the rock is generally quite massive.

Under the microscope, the feldspar resembles that described under norite proper. The reddish dust is usually, but not always, visible. The andesine carries it most frequently; when the plagioclase becomes labradorite, the inclusions are more grayish. The lamellæ are sometimes bent or broken by strain, and secondary twinning is also sometimes induced, but such a degree of metamorphism is rare. The orthoclase may be almost entirely wanting, or it may again make up one third of the feldspar. It sometimes becomes quite gray from inclusions.

The biotite is present in typical habit; it seems to be a somewhat less ferriferous variety than is characteristic of the diorites, and the axial angle is larger. Its pleochroism is X golden yellow, Y dark brown, Z brownish or greenish black. Rarely the colors are lighter than this. The biotite is an especially delicate indicator of the amount of strain which the rock has undergone, but, as stated above, any marked amount is rare.

The hypersthene is, of course, the essential constituent of the whole norite group. It usually occurs in stout, rounded prisms, which are idiomorphic unless the ferromagnesian minerals are unduly crowded. In the finest grained rocks, the crystals are small and often clustered together, and even in the coarser varieties, the hypersthene is sometimes present in large aggregates of small irregular grains. Sometimes there is a tendency for the ends to fray out, as it were, and alteration then begins at this point. The depth of color and pleochroism vary directly with the amount of iron. Enstatite rarely occurs in the norites; bronzite, with a faint pleochroism, is more common; but hypersthene, of varying degrees of pleochroism, color and relief, is the typical orthorhombic pyroxene. X varies from deep red to reddish yellow or pink; Y from yellowish brown to dirty yellow or pale yellow, and Z from bright to pale green. Extinction is, of course, parallel. In basal section, it shows the characteristic crossed prismatic cleavages parallel to (110); the pleochroism is then rather faint, but the figure of the obtuse bisectrix distinguishes the mineral from monoclinic pyroxene. The fine parting of hypersthene parallel to (010) is usually well developed, and the characteristic ilmenite

inclusions are oriented with respect to this. These inclusions are practically always visible with the high power objective, and they often become very large. They are usually reddish and are seldom opaque, although when abundant they may almost obscure the pleochroism of the mineral. By reflected light, they exhibit an excellent metallic luster, resembling that of phosphor-bronze. They are in many cases recti-triangular in shape, but sometimes four-sided and often irregular. Alteration of the hypersthene is fairly common, usually to bastite, which is then geometrically oriented on the altered pyroxene. Alteration may begin at the ends, or the bastite may be flecked over the surface of the crystal. Its color is yellowish green, and it practically lacks pleochroism. Uralite may occasionally form on the hypersthene; it is distinguished from the bastite by its pleochroism, deeper color and more fibrous habit.

The opaque mineral in these rocks is chiefly ilmenite, in large irregular masses, magnetite being usually markedly subordinate. Pyrite is not uncommon, but pyrrhotite is rare. Apatite occurs in all quantities, usually in small, well defined rods, but sometimes in large crystals, several millimeters long. The crystals show a sharp hexagonal outline in cross section, with frequently a member of fine parallel rod-like inclusions—so fine in fact that they resemble the parting which is sometimes developed in corundum parallel $(10\bar{1}1)$. The figure is the same in the two minerals, and the relief and birefringence seem to be higher in these apatites than usual. In one rock in which the identity of the mineral was doubtful, a test for phosphoric anhydride was made, but the high percentage (2.45) removed all suspicion of its being corundum. This latter mineral was not noticed in any of the normal igneous rocks of the series.

In several slides, hornblende (usually light brown) was present in subordinate quantity, marking a passage to the biotite hornblende norites. Augite may also enter, to indicate the transitional phase to the biotite augite norites, but biotite norite appears to be a fairly constant type.

Biotite Augite Norite (Hyperite)

Biotite augite norite is the most important of all the norites, and from its central position it gives the impression of being the fundamental norite magma. There are three large areas, two of which are probably connected as mapped; two smaller ones, one on the west border and the other on the eastern, and a third located in the pyroxenite area. It also frequently occurs in the complex on Montrose Point, associated chiefly with the pyroxenites. Williams's specimens are taken mostly from this

locality, although he mentions the western portions of both of the other areas.

This rock closely resembles the biotite norites, being medium grained and either dark pink or dark gray. One or two light pink specimens have been taken, but this variety is uncommon. The rock seldom shows any metamorphism.

The feldspar is identical with that in the biotite norites, the orthoclase being present in about the same quantity. The plagioclase is usually andesine, but in one of the light pink specimens mentioned above, it was oligoclase, and when the rock is dark gray it may be labradorite. The hypersthene and biotite occur as described under biotite norite. Green augite is the other essential mineral in this rock, and it appears to be closely related to the hypersthene. In shape, the crystals resemble each other strongly, and the augite often carries inclusions identical with those occurring in the hypersthene. These are clustered in the center of the crystal and are often so abundant as to render it dark reddish brown, but the margin usually is free and retains its clear green color. The color is about that of the Z ray of the orthorhombic variety. In many cases, an intimate intergrowth of augite and hypersthene was observed, a patch of pleochroic hypersthene appearing in an augite crystal, with the cleavage and inclusions coincident. The augite may, of course, be distinguished by its lack of pleochroism, its extinction angles of 40°-50°, its higher birefringence and its interference figure in basal section. Both simple and polysynthetic twinning were occasionally noticed in the same region, although these are both more common in the pyroxenites. Alteration is similar to that of the hypersthene, except that chlorite and hornblende are the common products.

The ferromagnesian minerals constitute in typical specimens from one-third to one-half the rock, but their mutual proportions vary considerably. The hypersthene makes up usually about one-half, with the biotite and augite in subequal amounts; frequently, however, these will exceed the hypersthene in quantity. Original hornblende is rather rare.

The apatite may become very abundant in this rock; in one case, the little rods were so plentiful in the orthoclase as to constitute one-third or more of its bulk. Ilmenite is much more abundant than magnetite, and pyrite and pyrrhotite are not uncommon.

The order of crystallization of the ferromagnesian minerals is sometimes hypersthene, augite and biotite, and sometimes hypersthene and augite, and then biotite The orthoclase usually crystallizes last of all.

Williams does not recognize this member as a distinct variety; he groups all of the augite norites together. That the subdivision is a rational one,

however, is indicated by its areal distribution; and, as remarked above, it seems to be at once the most common and the most resistant member of the norite family. It is itself a transition phase from biotite norite to augite norite; it rarely shows relations with other types.

Quartz Norite

The remarkable rock, quartz norite, was found in only one area, at the extreme southern point of the series, where it lies between biotite norite and mica schist. This and similar quartz-bearing rocks were also found in the emery mines, but the peculiar conditions which undoubtedly governed the formation of these deposits tend to discredit the occurrence of such rocks over larger areas, and they will therefore be described in the economic section of this article. The patch in question might perhaps be relegated to the same category, as purely a contact development; but since there is no emery present, and since quartz is known to occur in other gabbros as a result of purely igneous[20] action, it is thought best to notice it here.

The rock in hand specimen is of a basic, micaceous. brownish gray appearance. In the slide, the feldspar is seen to make up about one-third of the rock, and about one fifth of it is unstriated. It is distinctly gray from inclusions and shows somewhat wavy extinction. In the case of the plagioclase, the twinning is often irregular. The quartz is present in considerable quantity and appears to be undoubtedly original. It is in fairly large grains, which fill the interstices between the other minerals. It is often cracked, and these cracks are only occasionally rehealed. The hypersthene constitutes about one-quarter of the rock. Its color is deep and its pleochroism strong, and it carries numerous inclusions. It is altering to bastite and apparently to hornblende also, in places. Only a few grains of the typical green augite were noticed. The biotite makes up about one-quarter of the rock; it is typical and somewhat altered, so that it has a greenish tint. The hornblende is largely secondary, but one or two (deep green) pieces may be original. Apatite is abundant, and there is considerable ilmenite and pyrite. Chlorite, bastite, hornblende and kaolin are the alteration products.

The rock has undergone a small amount of shearing, but the alteration is probably largely superficial. It appears to the writer that this rock is

[20] J. P. IDDINGS, "Origin of Primary Quartz in Basalt," Amer. Jour. Sci., (3), XXXVI, 208. 1888. This paper deals with a somewhat different rock, but quartz norite itself has been described by TELLER and VON JOHN, "Beitrage zur Kenntniss der dioritischen Gesteine von Klausen in Südtirol," Jahrb. der k. k. geol. Reichsanstalt, XXXII, 589-684. 1882.

due to a reaction between the mica schist and the biotite norite, although it is, of course, impossible to explain why the same conditions should have given rise to the syenite to the west of it or the diorite to the east. That the quartz in the rock of this little border patch is entirely adventitious is quite improbable; its rather frequent occurrence in the rocks associated with the emery would indicate that certain peculiar conditions are requisite for its formation and that these conditions had been satisfied here.

Augite Norite

Augite norite is a basic and comparatively unimportant facies of the biotite augite norite magma, having been found in two small patches on the borders of the latter area and as streaks in pyroxenite on Montrose Point. The smallest is at Montrose; the other, about half a mile east of Pleasantside. Its position would thus seem to indicate that it is merely a local segregation, derived by the loss of biotite. In the hand specimen, it resembles hornblende norite most closely, since there is no biotite. The rock is compact, dark gray and of medium grain. Under the microscope, there is little of note. In the patch at Montrose, there is a trace of biotite, while the augite and hypersthene are subequal in amount. There is a remarkable development of apatite in this rock, sharply crystallized in very large grains. In the rock from the other patch, there is no biotite; the hypersthene is somewhat less in amount than the augite, and both are characterized by such an abundance of inclusions as renders them almost opaque. Bastite, chlorite, epidote and kaolin are the well-developed alteration products. The streaks on Montrose Point are similar to the last, except that the plagioclase is more acid (approaching oligoclase) and the orthoclase abundant, being about one-third of the feldspar. The hypersthene is light in color and in pleochroism and is often in small elongated grains. The augite is in larger crystals, with numerous black inclusions, and there are a few grains of brown hornblende.

Hornblende Norite

Hornblende norite is the third important member of the norite group. The bulk of it occurs in the large area to the southwest of Pleasantside; the rest in a small patch half a mile to the southeast. The former is entirely surrounded by norites, while the latter is on the edge of the norite district.

The rock in the hand specimen can usually be identified as a norite by the pink or (when altered) brownish color of the feldspar. The absence

of biotite in a norite may generally be taken to indicate this variety. The identification of the hornblende in the presence of hypersthene is difficult, owing to the peculiar luster of the latter on cleavages. Occasionally, however, the hornblende occurs in slender black rods, whose long axes are roughly parallel, when it is unmistakable.

In thin section, the feldspar resembles that of the other norites. The plagioclase is usually a trifle more basic than in the others, being generally either a basic andesine or a labradorite. In one case, microperthite was found, but in another, the plagioclase was almost bytownite. The orthoclase is perhaps less abundant in hornblende norite, though almost always present. The hypersthene is usually deep in color and pleochroism. The hornblende seldom resembles that of the diorites, being generally coarser and of the brownish variety. The greenish tint is usually present, however, though faint. The pleochroism is good: X dark brownish green, Y dark brown, and Z yellow, with the usual absorption formula. The alteration is to chlorite. Biotite and augite are not infrequently present in relatively small amount. Apatite is often found in great abundance, size and perfection, and ilmenite is also common in large irregular masses. Titanite is rarely present in moderate amounts.

The order of crystallization exhibited in this rock is often peculiar. In many cases, the hypersthene, biotite, augite and even plagioclase seem to have preceded the amphibole, which then occurs in large irregular plates containing all of the other minerals excepting orthoclase. The structure then approaches the poikilitic, this term having been coined by Williams in fact to describe a similar feature in the hornblende of the hornblende pyroxenites of Stony Point.[30] In other cases, the plagioclases are outlined by irregular streaks of ilmenite, so that in two respects a somewhat extraordinary reversal seems to have taken place.

From the frequent presence of augite and biotite in small amounts, the hornblende norite seems to have its most pronounced relationship with biotite augite norite. It is, however, most frequently in contact with this rock. A larger increment of biotite than is usually seen results in the less common biotite hornblende norite. In the smaller area, however, it appears to grade into the diorite by loss of hypersthene, the variety of hornblende being the same in both rocks.

Biotite Hornblende Norite

An area of hornblende norite which carries biotite in addition, lies just southwest of Dickerson Hill. It may be placed in the same cate-

[30] Amer. Jour. Sci., (3), XXXI, 30. 1886.

gory as the augite norite, both being derived by subordinate change from a much more important variety. The rock, however, is important as the connecting link between the norites and the diorites; it finds a further transitional phase in some of the latter, which carry hypersthene or enstatite.

The rock is the customary dark gray and is of medium grain. The feldspar usually constitutes two thirds or more of the rock. It is chiefly labradorite, there being little unstriated feldspar present. The hypersthene is a little more abundant than either the biotite or the hornblende. The latter mineral is of the brown variety. Apatite is generally abundant, and ilmenite is present in the ordinary amount and habit. Magnetite and pyrite are not abundant.

Olivine Augite Norite

Olivine augite norite, which is the most basic of all the norites, has been found in only one small area, half a mile south of Pleasantside. It is situated on the border of the norite district, where it adjoins the pyroxenites. No olivine was noticed in them at this point, although it may be occasionally present. The rock is evidently a local basic segregation of the biotite norite member.

The feldspar constitutes about three fourths of the rock and is almost entirely plagioclase, of the andesine-labradorite series. Of the dark minerals, green augite is somewhat the most abundant; it is occasionally intergrown with the hypersthene and always contains the olivine. The latter may be in large masses, or again it occurs in small grains. It is always strongly cracked, but it is less altered than would be expected. What alteration there is has formed chiefly antigorite; there is little separation of magnetite. This makes up about one fourth of the ferromagnesian minerals, and the hypersthene, which has begun to alter to bastite, nearly one third. There is a little biotite, generally in small flakes. Ilmenite, magnetite and apatite are not abundant.

Hornblendite

Hornblendite is not common, being known in four small areas only. One is located at the northern end of Lake Meahach, another a mile south of Montrose; these are both in the main diorite area, and there is little question as to their derivation from the diorites by local segregation, due to loss of feldspar. The others are in the pyroxenite district, located respectively about a mile east and half a mile west of Dickerson Hill. The latter appears to be an altered pyroxenite, the hornblende

having been derived by paramorphism from augite. In the former area, the coarse green hornblendes often contain patches of altered but still recognizable augite, and these are undoubtedly secondary; but some of the hornblende may well be original. If this be so, the primary rock was a hornblende pyroxenite. Finally, hornblendite occurs in the network on Montrose Point, apparently there also derived by paramorphism from pre-existing pyroxenites. These two modes of origin thus appear to have both been operative in the formation of the hornblendites.

The rocks are easily recognizable in the hand specimen; they are usually medium coarse in grain and glistening black in color, with practically no white minerals. In the rock of the first patch referred to (at Lake Meahach), there is a little feldspar present, less than one-fifth of the rock; a small proportion of it is unstriated. The hornblende constitutes the great bulk of the specimen; it is pleochroic from yellow to dark brownish green in some cases, while in others it is distinctly brown, with a very small extinction angle. These two varieties may occur together in a single specimen. Sometimes the magnetite inclusions become so abundant, especially in the green variety, that all light is shut off except at the margin of the crystal. Hypersthene may be present in small amount and biotite in larger quantity. The grain of the rock in this area changes very suddenly from coarse to unusually fine.

In the area south of Montrose, the rock is similar to the above. The hornblende is always brownish green, with extinction averaging about 20°. Biotite is a trifle more abundant and occurs as aggregates of crystals in the hornblende. Irregular masses of pyrite and pyrrhotite are common. Calcite has developed to some extent.

In the more westerly of the two other areas, the rock is much the same, but the brown hornblende is apparently pseudomorphic after augite, and traces of the latter may still be seen. There is a moderate amount of biotite and several distinct alteration products, such as chlorite, calcite and quartz. There is, no feldspar.

The structure in the easternmost area has been described; the hornblende is sometimes in large coarse green crystals, and sometimes in a confused lighter green mass, which is partly chlorite. The remnants of the augite may still be seen.

The process of paramorphism is thus clearly indicated, and there can be no doubt that this is the common mode of origin of the hornblendites. In the two areas in the diorite, this is by no means impossible, since pyroxenite is apt to occur around inclusions in the main body of igneous rocks, and these two patches are both near inclusions. There is shown, however, in the writer's suite of specimens from this district, a fairly

complete gradation from a very feldspathic diorite to one in which the feldspar is distinctly subordinate to the ferromagnesian minerals; the hornblendites, moreover, resemble diorites in their sudden changes in grain, so that on the whole these two areas may best be regarded as basic segregations.

Pyroxenite

Pyroxenites form the most basic group found in the Cortlandt area, with the exception of an occasional specimen in which olivine runs over one-third and which may thus be classed as peridotite. Williams classifies all rocks containing olivine as peridotite and devotes the whole of his first paper to this group; most of them are considered by the present writer under the heading "Olivine Pyroxenite," below. The hornblende pyroxenites form a distinct group which Williams does not consider at all, *per se*. He merely mentions, moreover, the pyroxenites proper, which, as will be seen from the map, constitute nearly one-fourth of the whole series, and are thus the most important single rock type of all. They may be considered first.

Under this head are included all those rocks which consist almost entirely of pyroxene, whether it be monoclinic or orthorhombic. As a matter of fact, nearly all of them contain both of these minerals, and only occasionally would there be any warrant for calling a specimen augite rock or hypersthenite. Enstatite is quite common, moreover, and in one case what is probably hedenbergite was found, so that a multiplicity of names may be avoided by considering the pyroxenites as one group; and the field distribution seems to indicate that this is a rational procedure. The pyroxenites may be conveniently described under two heads, according as the color of the monoclinic pyroxene in thin section is pink or white, or green.

White pyroxenite, in which the augite is a light pinkish or greenish white, is by far the commoner variety. It occurs as mapped on Montrose Point (although the numerous other rocks which interpenetrate there are not indicated) and constitutes the bulk of the large area to the east. The patches of pyroxenite at Buchanan and just west and south of Montrose are also of this variety,[31] and it was only in the first two of these that the pinkish augite was noticed. By the entrance of olivine, it becomes the olivine pyroxenite of the series; and it may be noted here that while the areas in which the olivine is segregated are probably fairly definite, they are at the same time probably not as well defined as depicted on the map.

[31] The "fine black rock" which Dana describes as usually associated with the "limestone areas" is merely a fine pyroxenite.

All of the important emery developments are located in the eastern pyroxenite area, although a local development of a more acid rock often constitutes the immediate wall rock.

These rocks cannot be distinguished megascopically from those carrying small amounts of olivine, but their general identity as pyroxenites is at once apparent. When fairly fresh, they are dull black; upon moderate alteration, they assume, in many cases, a reddish brown color, and strangely enough when badly altered, they become gray and look like an entirely fresh rock. The reddish rock is common in the region around Salt and Dickerson Hills; the gray, farther to the east. They always retain their toughness, but the rock, especially when it contains olivine, will often disintegrate under the hammer, rather than break. That the rock is the most resistant in the series is evidenced by the fact that the two highest hills in the county (Dickerson and Salt Hills) are composed of it. Very perfect jointing is often developed in the pyroxenite. The grain varies greatly but is generally medium fine. In the district just west of Dickerson Hill, however, it becomes very coarse, containing crystals of hypersthene and diallage one inch or more long and frequently masses as large as one's fist: and this coarse facies occurs in other places also.

Under the microscope, it is seen that the bulk of the rock is generally made up of a light colored pyroxene, which is probably augite (fassaite). It is a uniform light greenish gray in color, with extinction of 42°–45° in the vertical zone (in diopside $Z \wedge c = 38°$). The alteration, moreover, is usually to antigorite or to brown hornblende or chlorite, so that too much FeO is indicated for a diopside. Furthermore, the analyses indicate a mineral carrying 2 to 4 per cent. Al_2O_3, so that it seems to be an augite. The mineral sometimes occurs in idiomorphic grains, but it is ordinarily in an entirely allotriomorphic condition. The grains are sometimes clear and coarse, and sometimes exhibit the fine parting of diallage (generally parallel to 100) in great perfection. They often carry a notable amount of fine black rod-like inclusions, which are very different from the inclusions in the green augite of the norites, although occasionally the latter are found and constitute a typical diallage. Simple and polysynthetic twinning are common, and the latter especially reaches a high degree of perfection in these rocks. The other and much less common variety is similar in every respect excepting color; this is a light brownish pink, with very faint pleochroism. Its color is very possibly due to TiO_2, but the rock containing this mineral appears to be intimately associated with the normal variety. The alteration of the augite is almost always perceptible and often far advanced; the common

products being antigorite and brown hornblende, or more rarely chlorite. The light green antigorite forms in a confused fibrous mass over the original mineral, the alteration starting from the border of the crystal. The antigorite may form in considerable amount before the polarization of the augite is destroyed. The brown hornblende forms in sharply defined masses along the cleavage rocks, in strong contrast to the antigorite. Calcite and quartz are accessory products.

The orthorhombic pyroxene in these rocks is less ferriferous than in the norites. Hypersthene in rather small rounded grains set in the augite, and less altered than that mineral, is nearly always present. Its color and pleochroism are usually not strong, however, and it grades into bronzite and enstatite by a loss of iron and a concomitant decrease in refringence and birefringence and in the optic angle about Z. These colorless varieties are difficult of distinction from the white augite in plane polarized light, but under crossed nicols, of course, the orthorhombic symmetry becomes evident. Like the augite, the enstatite is usually (but not always) allotriomorphic. Fine parting is generally well developed, and the characteristic small inclusions, regularly arranged, are common.

The rock is usually at least half made up of the augite, although the proportions of the monoclinic and orthorhombic pyroxenes vary greatly. Sometimes an almost pure enstatolite will be developed; pure augite rock is known, but hypersthenite is rare. The most common type consists of augite to the extent of from one half to two thirds, with hypersthene and enstatite—the latter usually the more abundant—for the other chief constituent. Hornblende in small quantity, and generally basaltic, is very common, especially in the Montrose Point area. Biotite is rarely present. Traces of feldspar, chiefly unstriated, are not uncommon. Apatite is practically absent. The chief ore is pyrrhotite; pyrite and chalcopyrite are less common; ilmenite and magnetite are always present, usually in small quantity, and chromite is known.

Green pyroxenite was found in only one patch, where it adjoins and probably surrounds a limestone inclusion. It is located on the post-road between Montrose and Buchanan. The available outcrops were all very near the contact, the rock being greenish black and felsitic. Under the microscope, it appears that the great bulk of the rock is composed of an apple-green pyroxene in small crowded grains. The extinction angles run from 30°–38°. In basal section a somewhat eccentric bisectrix figure is obtained. The refringence is a trifle higher than usual in a pyroxenite, and the birefringence lower. Pleochroism is more distinct in some grains than in others, though it is nearly always visible; when most distinct X is pale brownish, Y pale green and Z apple green, or X may be pale green.

Some of the larger grains show almost colorless centers. The cleavage is always coarse, and there is little suggestion of a diallage parting; in basal section, the cleavages intersect at 87°. $\rho > v$. It appears from these characters that the mineral is a member of the diopside series, probably salite or hedenbergite, or possibly (from the pleochroism) a lime diallage. Titanite is scattered through the rock rather plentifully in small wedge-shaped grains. Very small grains of what is probably wernerite are not uncommon, and there is a very little quartz. Opaque minerals are almost lacking.

The peculiar combination of minerals in this rock indicates that its relation with the associated limestone is very close. All of them, except the very small amount of quartz, are lime minerals, and all of them may be contact minerals. There is little doubt that the rock represents a clear case of contact between limestone and probably diorite; and similar, though entirely abnormal, mixtures are not uncommon in the district and will be described below.

Hornblende Pyroxenite

Pyroxenites containing sufficient amounts of hornblende to place them in this class are most common on Montrose Point, although two other small areas exist: one just south of Salt Hill, and the other two miles north of the first. Williams describes this class only in their peridotitic phase; they are then most abundant on Stony Point, though known in the extreme eastern end of the main area. The hornblende pyroxenites have originated in all the cases examined by local increase of hornblende in the typical pyroxenite described above, although conceivably a partial paramorphism of the pyroxene would give rise to a similar rock.

These rocks cannot be distinguished in the field unless, as is often the case, the hornblende occurs in very large individuals with the other minerals imbedded in it. This is the type development of the poikilitic structure which led Williams to coin the term. The hornblendes may reach three or four inches in width, and their glistening black surfaces, interrupted by small included grains, is an unmistakable feature. On Montrose Point, however, this structure is often lacking entirely, the hornblende having crystallized simultaneously with the other minerals.

Under the microscope, the proportions of the various minerals are seen to vary considerably, according to the degree of completeness which the segregation of hornblende has attained. The typical greenish gray augite is always present and may constitute as much as two thirds of the rock.

Hypersthene, often in the beautifully pleochroic clear rounded grains,

and enstatite are present as stated under pyroxenite. Small amounts of olivine may be present, but if at all important the rock is classified as olivine pyroxenite. Calcite, quartz, chlorite, antigorite and hornblende may occur as alteration products; and in one more acid variety, containing some feldspar, zoisite was found, typically developed. The hornblende is the essential constituent in this class, making up from one third to two thirds of the rock, and yet it seems to differ in the various patches. It is usually of the basaltic variety, rich brown in color, and pleochroic from dark to light brown. The refringence and birefringence are higher than in the green variety, and the extinction angle is smaller. It is this variety that usually gives rise to the poikilitic structure; it seems generally to have crystallized last. In one specimen, the hornblende was apparently basaltic but had become a pale brown, and the crystals were often decolorized in the center. Again it may be of the coarse greenish brown variety which is characteristic of the hornblende norites, so that the hornblende pyroxenites do not seem to be a very well defined member of the series.

Olivine Pyroxenite

Olivine pyroxenite forms the last class of any importance; rocks in which the olivine runs over one third and which are then classed as peridotites, are rare. They seem to occur, moreover, in the centers of the areas of olivine pyroxenite; and since they merely mark the culmination of the segregational process which has led to the formation of these areas, it was thought unnecessary to differentiate them on the map. As stated above, the areas occupied by the chrysolitic rocks are rather vaguely defined, and owing to the difficulty of distinguishing these rocks in the field, their extent on the map is only as close an approximation as could be attained by collecting and sectioning a large number of specimens.

The weathering of the olivine rocks is beautifully shown in the two eastern areas. The decay of the olivine causes a disintegration of the rock into a coarse red sand, whose fragments are the grains of augite and hypersthene. This is much prized as road metal, and it is used extensively through the eastern part of the district. It is in effect a fine, resistant, homogeneous gravel, found ready crushed and sifted, and is excellent as a road covering. It is not, however, of like benefit to the farmer, being too ferriferous to be fertile. On the hills, it favors especially a peculiar flora, with an abundance of such trees as cedar and hemlock. The topography of this region is rather striking, there being numerous rounded hillocks, whose shapes are due to the melting away of the rock masses which compose them. These ledges when artificially exposed show

their peculiar softened shape, with rounded masses often projecting high above the general level of the rock. This is well shown at Chase Corners, just northwest of Dickerson Hill, as pictured in Plate III, fig. 1; the effect is rather striking, when it is recalled that the other rocks of the series are usually found planed smooth by glacial action.

As above stated, these rocks resemble in general aspect the pyroxenites, although closer examination may reveal the small yellowish green grains of olivine. It is only in thin section, however, that the rock may be accurately studied. The proportions of augite (usually the gray variety, but occasionally the pink), enstatite and hypersthene vary as recorded under the pyroxenites; almost pure olivine-augite rocks and olivine-hypersthenites are known. Hornblende, usually basaltic, is a fairly constant component, though it seldom occurs in important amount. The olivine is present in amounts varying from one-fifth to one-third of the rock. It occurs in typical grains, usually rounded, but sometimes exhibiting a distinct crystal outline. Usually besides these large grains (which may reach 3 mm. in size), there are numerous little ones scattered throughout the augite. The mineral is colorless but often carries magnetite inclusions in the form of minute rods; this feature is, however, better developed in the peridotites of Stony Point. The alteration is exhibited in all stages. Sometimes the mineral is nearly all serpentinized, with only occasional little bullets of olivine remaining, while again it may be almost perfectly fresh, even when strongly cracked, and when the augite shows distinct alteration. The characteristic mesh structure is always developed on alteration. The product is, of course, serpentine. Antigorite is the most common variety, chrysotile is somewhat more rare and bowlingite less frequent. Magnetite separates out in varying quantity. According to Williams, whenever the mineral comes in contact with feldspar a diopside-actinolite reaction-rim is formed, such as he has figured;[32] but feldspar has not been found in contact with the olivine in the rocks of the main area, so that this effect is not a common one. A similar phenomenon, between olivine and biotite, is described and figured below.

Peridotite

Peridotites are merely exceptionally basic phases of the rock last described; and their relations to that type have already been discussed. They do not differ in any respect except the proportion of olivine; this mineral, however, in several cases constituted about three fifths of the rock, and in one instance was almost unaltered, though badly cracked.

[32] Amer. Jour. Sci., (3), XXXI, 35. 1886.

These cases were all found in the two eastern areas, although less pronounced ones occur in the Montrose Point district. All of these rocks would be classed by Williams as augite peridotites (picrites) which he thought occurred in the highest development on Montrose Point. He describes at considerable length another group from Stony Point, however, which is not typically represented in the main area—the hornblende peridotites. The nearest approach to these rocks is to be found in the hornblende pyroxenite area on the south side of Montrose Point; but these contain olivine to the extent of more than one-third only exceptionally. Oddly enough, however, Williams, who, after all, studied only a small part of the whole area, felt that they were so important a member of the Cortlandt Series that he proposed the name "Cortlandtite" for them, and rocks consisting of olivine and hornblende are now widely known by this name.

Fig. 1. *Poikilitic Relation of Biotite and Olivine in Peridotite.* Sl. 166

A rather extraordinary rock, somewhat analogous to the so-called cortlandite, does, however, occur in a small patch on the extreme eastern edge of the series. This in the hand specimen exhibits the poikilitic structure *par excellence,* but biotite, instead of hornblende, is the host. This occurs in individuals often several inches across (although by reason of the abundance of the included minerals, it makes up somewhat less than one-third of the rock), and under the microscope it is extraordinary for the abundance of its inclusions. These are of a sharp, brownish black substance, probably magnetite, and are so abundant in the center of the grain as to render it opaque, but the periphery and a margin around each included olivine is entirely clear. On the extreme edge of the biotite in the latter case, however, there is a narrow band of magnetite grains, and surrounding, or nearly surrounding, the olivine is a wider zone of pale green pyroxene in rectangular blocks (fig. 1). This appears to be a reaction rim, although the pyroxene zone is not entirely universal. Basaltic hornblende, without inclusions, is fairly abundant, and hypersthene and enstatite make up nearly one-third of the rock. The olivine is also present in about this amount; white augite is almost lacking. Alteration is apparent, but is not severe.

As the culmination of the basic development along this line, we have

several occurrences of serpentine. These are probably generally, if not always, dikes and they will be described under that head. They always occur in the pyroxenite area, however, and may represent local segregations of olivine. They would thus once have been dunites, since only serpentine, showing mesh-structure, is contained in them. If they are genetically related to the peridotites, however, it is difficult to understand their complete alteration; and while their field relations cannot be definitely established, they may be provisionally considered as dikes.

DIKE ROCKS

Dikes are fairly common through the district and are usually small; and the following list is therefore probably by no means complete. Aside from those within the area itself, an excellent development of chiefly basic varieties occurs on Verplanck Point, where the dikes ramify into the limestone and schist. The abundance of pegmatite dikes in the northern part of the district has already been remarked. The complex of rocks on Montrose Point, in which, as Williams says, "each rock includes and forms dikes in every other" is interpreted as a case of true differentiation, rather than as a network of dikes; and the rocks have therefore been considered above. A careful study of the dikes of the series with regard to their mutual time relations would probably be of great value in indicating the relations of the plutonic types; for if the dikes had followed the laws which govern their successive differentiation in other districts, it might be inferred that the plutonics had done the same.

Aplite

The aplite dikes are usually small and not especially common. They occur chiefly north of Pleasantside. They are, of course, fine grained and consist of muscovite, orthoclase and quartz, with small amounts of plagioclase and biotite and with zircon and magnetite as the common accessories. They are, perhaps, slightly more acidic than the granites, but their composition does not differ greatly from the latter.

Pegmatite

Pegmatite is probably the most common dike rock of all. It was noticed especially in narrow veins or dikes in many of the more northerly emery cuttings. The pegmatitic structure is generally well developed, and the component minerals are as usual. The largest and most striking occurrence of the rock appears about 200 feet south of Montrose station,

where a large irregular mass outcrops on the west side of the railroad. Its relations are rather obscure, and its size if fully exposed would probably be about 60 to 80 feet, but there can be little doubt as to its identity as a dike. Occasional blotches of a fine grained gray substance are included in it. The true pegmatitic structure is not well shown, this name being applied because of the coarseness of its texture. About 30 feet to the south lies one of the schist inclusions described below; between the two the country rock (biotite augite norite) is altered to a diorite, somewhat gneissoid, but this is probably due to the schist rather than the pegmatite.

Dacite Porphyry

The very remarkable rock, dacite porphyry, is known from only one locality, viz., about 300 feet up the hill east of Montrose station. It outcrops in the gutter of the road for about ten feet (though it may be traced for 75 feet), and this outcrop is about three feet wide. By differential weathering, it projects about three feet above the ground, and its jointing and its white color, combined with its odd position, cause it to look at a glance exactly like a stone wall. In thin section, the rock is seen to be composed of a moderate number of large idiomorphic feldspars set in a mosaic of quartz and feldspar grains. The phenocrysts are almost never striated, but Williams[33] states that all of the feldspar of the rock has a specific gravity of 2.63–2.67, so that it must be oligoclase and andesine. The phenocrysts never show resorption, but usually exhibit beautiful zonal growth. The quartz is all in the groundmass, and some of the small feldspars are striated and seem to be oligoclase. Biotite, hornblende and muscovite, some of the latter probably damourite, but not all, occur in rather small quantity. In the groundmass, the grains often appear to be interlocked, as though the rock were a kind of augen gneiss, but the perfect outlines of the phenocrysts and the distribution of the muscovite, as well as the field relations, preclude this.

Dioritic and Gabbroic Dikes

Various types of the dioritic lamprophyres constitute by far the most common group of dike rocks. They are especially abundant on Verplanck Point, although found quite abundantly elsewhere, especially through the southern part of the district. The different types, of course, exhibit no preference for any particular plutonic rock. Only in the limestone on

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[33] WILLIAMS calls this rock a bed of porphyritic quartz mica diorite, (Amer. Jour. Sci., (3), XXXV, 446. 1888.) and DANA a granitoid micaceous quartzite (*Idem*, XX, 218).

Verplanck Point was any contact metamorphism observed: here the dikes are gabbroic (camptonite), and cause the formation of diopside, actinolite or hornblende and pleonaste in the limestone. Only occasionally is a typical minette, vogesite or kersantite found; usually the orthoclase and plagioclase, and the biotite and hornblende, are subequal in amount. Green augite has been found only in the dikes on Verplanck Point, where they radiate into the limestone; these, however, are typical camptonites. Furthermore, there is seldom any serious alteration, such as is described by Rosenbusch in the type lamprophyres, although this is a less essential feature. Minette has not been found typically developed: the usual variety is a basic one and might almost as well be called either of the following. Vogesite is quite typically developed in a number of places; the orthoclase constitutes two thirds or more of the feldspar, and hornblende, which is usually greenish brown, though sometimes green, is distinctly predominant over the biotite. Augite, however, has been seldom found in them. Kersantites, though not typical, are found abundantly on Verplanck Point, and also on Montrose and Stony Points. They are merely fine grained mica diorites with considerable hornblende. Camptonite occurs on Verplanck Point, as stated above. The classification of these rocks according to Rosenbusch is thus a difficult matter, and they had best, perhaps, be regarded as dioritic and gabbroic dikes.

Hornblendite

Only two dikes of hornblendite were found, one on Verplanck Point, in limestone, and the other in one of the emery pits on the hill east of Pleasantside, in diorite. In both cases, the rock was composed almost entirely of bright green hornblende, with a very subordinate amount of biotite. Apatite, which is ever-present in the diorite dikes, is practically lacking.

Serpentine (Peridotite)

Three outcrops of serpentine (peridotite) were found, one two miles east of Montrose, another four, and the third about half a mile farther. The first is in hornblende norite; the others in olivine pyroxenite. The first and last are undoubtedly dikes, the former three feet wide and the latter about ten feet. The second outcrops on an old log road southeast of Dickerson Hill, and its relations cannot be definitely determined. If a dike, it must be at least twenty feet wide. In all three cases, the rock is greenish black, fairly soft and strongly jointed. In the first case, the structure of the serpentine is hard to work out. There are traces of

typical mesh-structure, though most of it has neither the antigorite nor the bastite habit. It most resembles the former, however, and a hypersthenite dike so completely altered would be a curiosity. There is also a small amount of sericite, quartz and biotite. In the other cases, the typical antigorite or mesh-structure, indicating the former presence of olivine, permeates the whole rock. Traces of altered white augite are still visible; but the rock was evidently almost entirely olivine. In all three cases, a considerable amount of magnetite is present.

ABNORMAL CONTACT ROCKS

The true igneous character of the series is proved by the frequent presence of contact action. This usually occurs along its borders, but several very peculiar and abnormal developments are to be found within the area itself which can only be explained by considering them as due to the contact action on the inclusions which are fairly common in the western part of the area.

Williams[34] has given such a minute description of what seems to be the characteristic type of border contact action that it would be superfluous to describe in detail the work which the writer has done along the same line. The general result seems always to be that the mica schist increases in alumina content as the massive rocks are approached; and this is attended by the formation of such aluminous minerals as staurolite, sillimanite, cyanite and garnet. A very striking feature, and one whose importance will be emphasized later, is the great increase in the amount of biotite, which at a point ten yards from the contact at Crugers constitutes the bulk of the schist; and magnetite is thickly scattered through the mica. Contained in the diorite itself at this point are numerous small schist inclusions, and these in like manner furnish excellent opportunity for the study of contact action. They are largely changed to pleonaste and corundum in some cases; in others to quartz; in others to staurolite and green mica. The first case resembles the emery from the mines very closely.

Along the limestone contact, which exists only on Stony Point and at Verplanck, contact action of a different kind has taken place. The common minerals developed are usually pale green amphibole and pyroxene; more rarely titanite, zoisite and scapolite are formed (these last were observed on Stony Point). Similar effects have been recorded by Kemp from the Rosetown area,[35] where the limestone contact is especially well shown.

[34] Amer. Jour. Sci., (3), XXXVI, 254. 1888.
[35] *Op. cit.*, p. 252.

The writer has observed several other instances, however, which would seem to merit description. The pale-green pyroxenite recorded above, occurring on the border of a limestone inclusion, is undoubtedly a contact facies, and may be recalled in this connection.

Wernerite Schist

Wernerite schist is found in a small patch at the cross-roads on Montrose Point, lying in the pyroxenite area. It has been only partly exposed by the excavation of an old clay pit at this point, but it probably is not more than several hundred feet long, extending northeast. In the field, it is distinctly gneissoid in appearance, the black bands being very distinct. It is very tough and has been planed off into a series of *roches moutonnées*, so that it is hard to sample. Under the microscope, it is seen to be made up of scapolite, pyroxene, titanite, calcite and pyrite. The scapolite seems to be wernerite, and the appended analysis as recast indicates that it is Me_4 Ma_1, which is a very calcareous wernerite. The mineral gives conclusive tests. It makes up almost three fifths of the rock. Associated with it is the calcite, which is very subordinate in amount. The pyroxene is similar to that found in the green pyroxenite described above, except that the grains are less crowded and have a prismatic shape. They are regularly aligned, and impart the gneissoid appearance to the rock. The pyrite and titanite are very variable in amount, occasionally becoming quite abundant. Since all of these minerals have been observed on the limestone contacts, there is little doubt that this patch represents an entirely absorbed inclusion of limestone. It is possible, of course, that the limestone is still present, though concealed, but the rock described exists over a zone 75 feet wide, at least.

Lying between this rock and the pyroxenites, in several places at least, a typical diorite is to be found.

On Verplanck Point, just west of the brick yards, and about 200 feet from the schist contact, a pyroxenite exists whose peculiarities might be taken to indicate a similar history. The rock is very hard and black, although in thin section a surprising amount of alteration is revealed. There is considerable pinkish augite in the rock, which appears to have altered largely to a greenish hornblende. Wernerite is present to the extent of nearly one third, in large and small grains.[36] Calcite is less abundant, and in part at least, it is derived from the augite. There are also biotite, apatite and plagioclase in small amounts. Although no limestone is visible near this rock, the wernerite would point to an included patch which had been partly or wholly absorbed.

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[36] F. C. CALKINS (Science, XXIX, 946. 1909.) notes the occurrence of "primary" scapolite in igneous rock, but also concludes that it is due to the absorption of limestone.

Garnet Rocks

On the southern border of the district, along the road at the foot of Salt Hill, is found a contact facies of very interesting composition. The outcrops are badly cracked and jointed, and the rock is friable and stained brown along these cracks. When fresh, two varieties may be distinguished, one pink and the other an ash gray, these two occurring within 30 yards of each other.

The former variety is of about the color of rhodonite; it is fine grained, but is thickly penetrated by flat gray tremolite rods. Under the microscope the pink mineral, which makes up more than half the rock, is seen to be garnet. It is practically colorless and always isotropic and is probably grossularite. The tremolite[37] is typical and constitutes nearly one third, and quartz makes up the rest. Rutile, in small sharp grains, with very high relief and birefringence, and a deep yellow color, is quite common. This rock is thus probably derived from an impure limestone, or possibly a calcareous schist, and presents an interesting contrast to the wernerite rock. The abundance of titanic oxide present is a curious feature in the contact metamorphism of the limestones; either as ilmenite, titanite or rutile, it appears to be always present, whereas iron and alumina are more typical in the case of the mica schists.

The gray rock in thin section is resolved chiefly into quartz and garnet. The latter is identical with that in the last, except in its color in mass. The most interesting and suggestive thing about this rock is the presence in rather small amount of both corundum and pleonaste; and magnetite is, moreover, thickly scattered over the slide. Notwithstanding its propinquity to the previous phase, the aluminous character of its components seem to indicate derivation from a mica schist rather than a calcareous rock.

The very abnormal developments which are associated with the emery may or may not be contact rocks; they had best be described, therefore, in conjunction with the emery.

INCLUSIONS

Inclusions[38] of schist (and occasionally of limestone and gneiss) have been alluded to frequently in the previous pages; they are quite abundant

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[37] KEMP mentions an analogous rock from the border of the Rosetown extension, composed entirely of tremolite (*Op. cit.*, p. 252.).

[38] Accidental xenoliths of this kind are of wide occurrence in other igneous districts. They have been exhaustively studied by LACROIX, "Les Enclaves Des Roches Volcaniques," 1893. The tendency of intruded rocks to carry them is discussed in "Geology of the Castle Mountain Mining District, Montana," Bull. U. S. G. S., 139. 1896.

in the district and are of especial interest from the standpoint of contact action. They were first noticed by Dana, who mapped[39] several of the larger limestone areas in the western part of the district. They appear to be most frequent in this area; in the region around Salt Hill they occur less commonly. In the main diorite area, however, they are much more numerous than is indicated on the map; there are many, especially near Crugers, that are too small to be shown; and near Salt Hill, they are too small and their relations too obscure for adequate representation on the map.

Dana maps three inclusions of limestone in the large diorite area, and all of these have been found by the writer to be a very quartzose schist, closely resembling limestone in appearance, but nevertheless of an entirely different composition. Either Dana, who was looking for limestone, mistook its identity on account of its peculiar appearance, or else it does contain calcareous layers which he happened to find and which the writer overlooked; but it is certain that it is essentially a quartz schist. It weathers in layers, however, which also tends to give it the appearance of limestone. It appears to be chiefly quartz in most places, with some feldspar and traces of muscovite; but it occasionally contains layers which are entirely similar to the Manhattan schist. It is usually considerably decomposed. In one case, it resembled a very fine gneiss, but other parts of the same inclusion were normal, and it was moreover very similar to an outcrop of schist on Broadway, the straight road running north from Verplanck. An outcrop of the schist (see map) is to be seen on the post-road, a short distance below Montrose, and the cliff behind Mackey's store at Buchanan contains two stringers of this rock imbedded in a somewhat gneissoid diorite, which to the west becomes pyroxenite (Plate III, fig. 2).

The inclusions are generally associated with rocks which show more or less evidence of metamorphism. This is so apparent that these rocks were first interpreted by the writer as parts of the schistose inclusions themselves, but their peripheral position would seem to indicate that they are true igneous rocks which have undergone some shearing; and this is borne out by the composition, which is that of a mica diorite. The strongly crushed gabbro is also found on the border of two of these inclusions.

The abnormal mineralogy of the schist is peculiar, although there is little doubt that it is Manhattan schist. The mica has evidently been largely altered or absorbed by the igneous rocks, leaving a very quartzose residue; and it would seem, therefore, that these inclusions may thus en-

[39] Amer. Jour. Sci., (3), XX, 195. 1880. A minute description of a number of inclusions is here given.

rich the surrounding magma in certain constituents, such as alumina. It will be recalled that the numerous small schist inclusions at Crugers, for example— are also distinctly altered, but often in exactly the opposite direction, so that magnetite, corundum, biotite, etc., are developed.

Only one inclusion of limestone was found, which was either overlooked by Dana or else its position on his rough map is not accurate. It occurs along the post-road a short distance above Montrose, and on the north the contact with the green pyroxenite described above is visible. It is about seven hundred feet wide and is a medium grained, thoroughly crystallized patch of the white Inwood limestone. The wernerite schist described above may be mentioned in this connection, since its characters would indicate that it is a thoroughly worked-over inclusion of limestone.

A single inclusion of a rock which appears to be undoubtedly a basal Highland gneiss was found. It is located on the shore of Lent's Cove, and it seems to be only about seventy feet wide and of a slightly greater length. It is almost entirely feldspar, which is very strongly kaolinized, but which seems to be albite. There are also streaks of chlorite in the rock; and the whole has a decidedly gneissoid aspect. It could not be a dike or a member of the Cortlandt Series; it is probably a xenolith of an ancient gneiss, although it might also be thought that the igneous rocks are thin over this area and that this outcrop represents a projection of the gneiss which underlies the series.

Structural Geology

There is little that might be called structural geology that has not been already discussed. Jointing usually occurs in these rocks, but always in moderate development. The weathering of the olivine pyroxenites has been noticed above, and the only other features of note may be now briefly considered.

DYNAMIC METAMORPHISM

The amount of shearing undergone by the Cortlandt Series is, as has been shown, slight but constant. It appears to vary somewhat among the different members. The granites, although they carry microcline, show strain in general to a very small degree. It is only occasionally that the norites exhibit any trace of the mortar structure, bent plagioclase lamellæ, wavy extinction, and twisted biotite that characterize the most metamorphosed types. In but one or two instances was any crushing seen in the pyroxenites.

In the diorites and gabbros, however, the case is different. The former group, as remarked above, shows perceptibly more strain than is to be

found in the granites, norites or pyroxenites, although at the same time it is not severe and is apparent in the hand specimen only in exceptional cases. The gabbros in two cases show a remarkable degree of crushing, such as would be characteristic of an augen gneiss, and such as was described by Lehman[40] in the "Flaser Gabbros" of Saxony.

Both of these cases, however, occur directly on the border of an inclusion; and those of the diorites which show a gneissoid structure are similarly located. Williams has described the crushing which is apparent in some of the types found in the "Butler Section"; it is here also very severe microscopically, but this section is located 150 yards west of the inclusion which runs northwest from near Montrose. In many of these instances, it is easy to take the strike and dip, but the cases of straining which were noticed elsewhere were relatively insignificant. It would thus seem to appear that dynamic metamorphism is usually or always confined to the borders of foreign inclusions; and if the district had undergone any amount of regional pressure, it would naturally be concentrated along the lines of weakness which would develop on the contact. This is the only explanation that would seem to account for such a localization of metamorphic effects.

It may be noted in this connection that dynamic action is also very perceptible at most of the emery developments in the district; it is evidenced not only by microscopic and megascopic shearing, but by faulting and veining.

ORIGINAL GNEISSOID STRUCTURE

Dana[41] describes in some detail a structure which the present writer believes to be of an original gneissoid character. As already stated, on Montrose Point, in particular, several very different kinds of rocks are associated in the most intricate way, often as successive bands;[42] and Dana cites one case in which biotite augite norite and olivine pyroxenite are found in alternate layers of constant grain only three or four inches wide. There are many other cases of less pronounced character, which are referred to by both Dana and Williams (*e. g.*, the Butler Section) and which have been seen by the writer. In another instance, a streak of the coarse dark pink norite was seen in a cliff of the black pyroxenite; the norite was coarser, if anything, than the latter, and was coarse, moreover, to its very edge, having thus none of the characteristics of a dike. The analyses of these types show their great chemical differences.

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[40] Über die Entstehung der altkrystallinen Schiefergesteine, p. 190. Bonn, 1884.

[41] Amer. Jour. Sci., (3), XX, 211 *et seq.* 1880.

[42] WILLIAMS refers to these as "dikes," but Dana evidently recognized that they were not of this character.

In the norite family, however, this structure is commonest and best developed. As remarked above, it seems to be a general rule that the finer grained a norite is, the simpler it is, *i. e.*, a very fine-grained norite is composed chiefly of feldspar with considerable hypersthene, while the coarser varieties carry in addition either hornblende, or biotite and augite. The fine-grained simple norite is never found in large areas, but always as inclusions in the coarser, and therefore more complex varieties. It often occurs in biotite norite, for example, as small, rounded flow-like patches, or again as streaks; or it may be banded with the coarser rock. In this case, the chemical difference is not so great, as the accompanying analyses show.

Now, if the simpler norite be not quite so fine grained, it will not be entirely pure; and this is the case in most places. In Plate IV, fig. 1, the mass of the rock is a biotite augite norite, while the white streak is merely a finer and therefore simpler facies, containing only small amounts of biotite and augite. In one place, it shows an included patch of the coarser rock. The ledge shown is about 20 feet high. Plate IV, fig. 2, shows the same thing in better development, so that the rock might easily be mistaken for a real metamorphic gneiss. A number of other equally good instances might be shown, for the structure is quite common; but these suffice to show its general aspect.[43]

From what has been said above, it is evident that this structure cannot be due to ordinary shearing, and we are therefore obliged to search for another explanation.

Eliminating Dana's idea of worked-over volcanic ashes, and Williams's suggestion of the ordinary regional metamorphism of igneous rocks, we are thrown back on some force concomitant in its action with the cooling of the rock. Since the several layers or streaks are always quite different in mineralogical composition at least and more or less so in chemical, it is evidently a question of magmatic differentiation. It is inconceivable that the structure be due to the differentiation of a magma *in situ* — after it had reached its present position—since the differentiation is into bands which bear no definite relation to the borders of the magma; and the idea of successive intrusions—first of a light band and then of a dark—is equally inapplicable, since even when there is a sharp line of demarcation

[43] The classic locality for this structure is on the Isle of Skye, in Tertiary gabbro, where it was first described as such by GEIKIE and TEALL. (Quart. Jour. Geol. Soc., I, 646. 1894.) It has also been described in wonderful development by A. G. HÖGBOM, from the Island of Ornö, just south of Stockholm. ("Zur Petrographie von Ornö Hufvud," Bull. of the Geol. Instit. of Upsala, X, 150.) F. D. ADAMS has noted a striking development of the structure near Montreal, which he will describe in a forthcoming paper.

separating two bands, the individual grains seem to interlock across the line. The only remaining hypothesis, therefore, is that of the intrusion of a molten mass already heterogeneous.

Harker[44] appears to favor the view that the structure is due to the approximately simultaneous intrusion of two different magmas, which would give rise to an interpenetration of the two. This would account for the banded structure, which always shows evidence of flowage and is seldom straight and clear cut. The assumption would be then, of course, that the mass would soon begin to cool and harden while resting quietly, as otherwise the two magmas might combine to form a third and homogeneous one. Harker's alternative view is that the mass was intruded as a unit, already heterogeneous, the two different magmas having been partly mixed before intrusion. Whichever be the correct theory, it is evident that in the Cortlandt Series the simple norite magma was very small in comparison with the more complex norite magmas, since the former is always as included bands in the others, while these latter cover considerable areas.

Relations of the Types, with Analyses

From the above description of the more salient characters of the Cortlandt Series, it appears that we have in it a fairly complete and very intricate complex, one susceptible and worthy of the most detailed study. In some places—*e. g.*, Montrose and Stony Points—the complexity of the mass is bewildering, while again we may have several miles of a fairly uniform rock. At times, as shown in the original gneissoid structure, the contacts are sharp and clear, although never showing contact metamorphism on each other, while again numerous cases have been noticed of one rock grading into another. Thus, for example, the biotite norite area at Lent's Cove grades into the biotite augite norite to the south by a perfect series of steps; similarly the augite norite at Montrose. Diorite becomes hornblendite, and pyroxenite becomes chrysolitic, by imperceptible gradations. Moreover, the different larger groups are similarly connected; the diorite just southeast of Pleasantside grades into the adjoining hornblende norite, and norite passes into olivine pyroxenite by way of olivine norite. An infinite number of species might be differentiated within this small area of twenty-five miles; in this paper only the unavoidable ones have been mentioned. The accompanying diagram (fig. 2), greatly modified from Williams, is designed to show in a rough way the relations of the species. The lines connecting the circles indicate the direction in which gradation has been most frequently observed.

[44] Natural History of Igneous Rocks, pp. 138 and 341. New York, 1909.

The variation diagram of the series (fig. 3) indicates a rather complex relationship. The pyroxenites alone, however, are responsible for the sharp curves; if they be disregarded, the variation curves of the several oxides will be smooth and simple. This would seem to indicate that the differentiation which led to the formation of the pyroxenites was of a

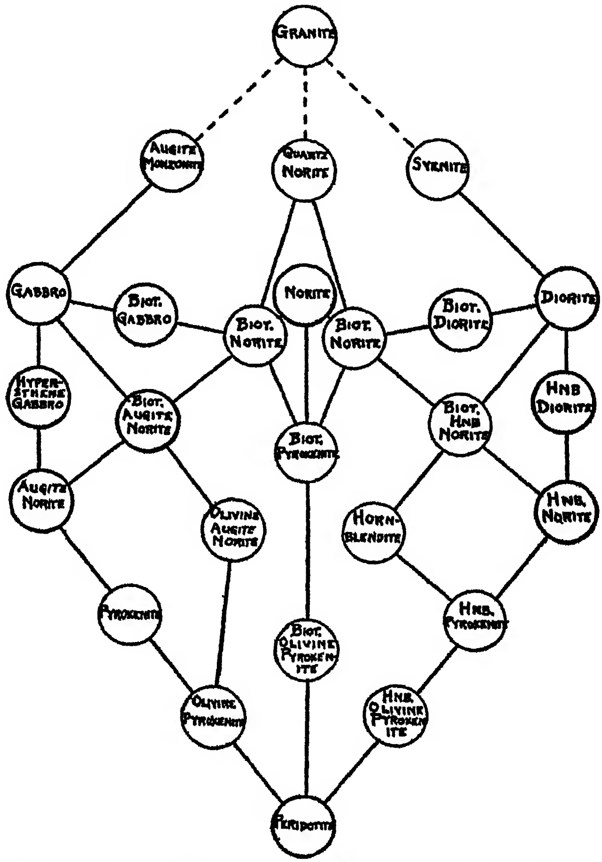

Fig. 2. *Diagram of the Relations of the more important Types of the Cortlandt Series*

peculiar character: that either they are derived directly from some other type, as the norites, or else that the primal parent magma underwent great changes between the times of intrusion of the pyroxenites and the other rocks.

An effort has been made to indicate under each type, in a general way, some of the more suggestive points which the map brings out. Thus the granites appear to have little connection with the main body, except as

they all belong to the same series. The norites occupy a central position in the area, being flanked by diorite and pyroxenite, and often, at least, protected on the north and south by more acid rocks. The biotite augite norite magma is the largest and is closely connected with the norite proper and the biotite norite; while the hornblende norite shows closer affinities with the diorites. The pyroxenites comprise the eastern third of the series, and possibly likewise extend to the west, since they are found on

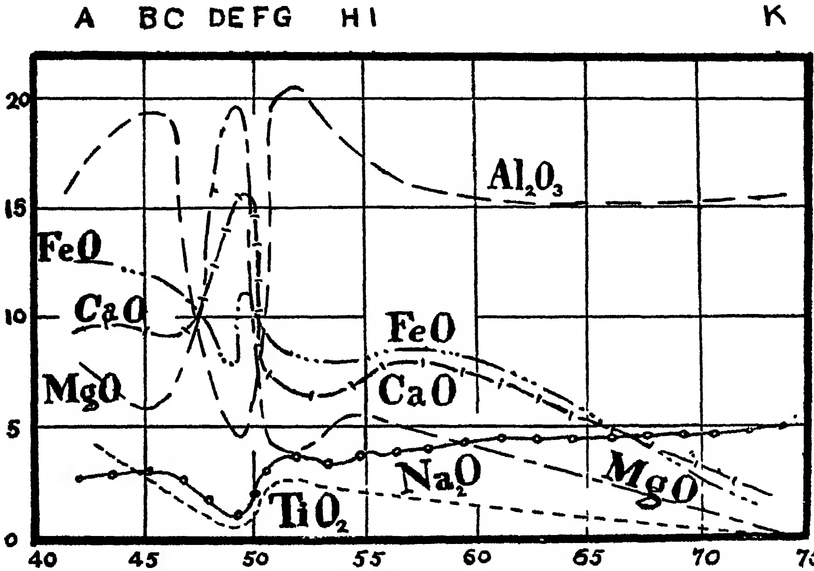

Fig. 3. *Variation Diagram of the Cortlandt Series*

A = Diorite; B = Hornblende Norite; C = Biotite Norite; D = Olivine Pyroxenite; E = Pyroxenite; F = Biotite Augite Norite; G = Norite; H = Gabbro; I = Augite Norite; K = Granite. (The rocks of the New Jersey and Connecticut extensions of the series are not included.)

Montrose Point and again across the river, on Stony Point. They become chrysolitic in apparently irregular patches. Finally, the diorites occupy an area to the west which contains most of the inclusions of the district; and in several places where there is reason to believe that inclusions have existed but have been absorbed, diorite is also found. Gabbro is found in two cases next to the limestone, and in two others adjoining schist, while syenite is in an analogous location.

The problem suggested by the location of these last rocks is a difficult one to solve. According to Harker,[45] the hybrid formed by the absorption

[45] Jour. Geol., VIII, 389-399. 1900. Also Nat. Hist. of Ign. Rocks, Chap. XIV. 1909.

of a sediment by an igneous rock is always of abnormal composition and constricted extent and is usually marked by such minerals as sillimanite, cordierite and wollastonite. By variation diagrams he proves that such a commingling would give rise to rocks whose composition might be predicted and which would not even approximate any known igneous flow. In the Cortlandt Series, we have this latter type well developed in the instances described; whether a normal igneous rock, such as syenite and gabbro, may be formed, despite Harker's arguments, is a question requiring more data. The rocks in question must be analyzed, and the variation diagrams constructed for them and for the surrounding magmas, before anything can be definitely said. It is interesting in this connection, however, to recall Daly's[46] theory of overhead stoping, which postulates extensive assimilation of the blocks which drop into a magma as it ascends. He has further developed this idea of abyssal assimilation,[47] until it resembles the marginal assimilation hypothesis which is supported by many French geologists.[48] If something of this kind has actually taken place in the Cortlandt Series, it is probably a fairly common process, since it has suggested itself in many parts of the world.[49] On the other hand, of course, the location of these rocks may be merely an accident of intrusion.

Little can be said regarding the mutual relations of the four fundamental magmas, since they are not yet sufficiently clear. The volcanic phase, the first in the normal cycle of igneous activity, is wanting. The normal order of intrusions in the plutonic phase is that of decreasing basicity, and this seems to have been followed in the Cortlandt. As already stated, the granites seem to have been intruded last, both from the evidence of the acid dikes in the more basic rocks and from their almost isolated position. The pyroxenites and norites, from their intimate relation in several places, were probably formed at about the same time, although not simultaneously, for their association is only local. The pyroxenites probably preceded the slightly more acid norites but had not hardened when the latter appeared. At the same time, however, the evidence of the variation diagram, as indicating a much more complex relationship, must not be lost sight of. The diorites were probably still later. Here again, however, we are confronted by the suggestion of hybridism in the occurrence of gradation from hornblende norite into diorite, for example, and a further discussion of these problems would be fruitless in view of the comparative scantiness of our data.

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[46] "The Mechanics of Igneous Intrusion," Amer. Jour. Sci., (4), XV, 269, and XVI, 107. 1903. Also "The Geology of Ascutney Mountain, Vt.," Bull. 209, U. S. G. S. 1903.

[47] Amer. Jour. Sci., (4), XXII, p. 195. 1906.

[48] See for example "Contribution à l'etude du granite de Flamanville," Bull. carte géol. France. 1898.

[49] See M. Weber, k. Bayerischen Akad. der Wissenschaften, Dec., 1910.

ANALYSES.

1. Granite, Cornell Dam Quarry. Analyst, Elwyn Waller. Privately communicated by C. P. Berkey. Magmatic symbol, I. 4. 2. 4. *Lassenose.*
2. Granite. Mohegan Quarry. *Idem. Lassenose.* (Near *Toscanose.*)
3. Diorite, Buchanan. Analyst, G. S. Rogers. Symbol, III. 6. 3. 4. *Limburgose.*
4. Gabbro, S. E. of Salt Hill. Analyst, H. T. Vulté. J. F. Kemp, Handbook of Rocks, 1908, p. 72, No. 3. Symbol, II. 5. 3. 3. *Shoshonose.*
5. Norite proper, 1½ miles S. of Peekskill. Analyst, G. S. Rogers. Symbol, II. 5. 3. 4. *Andose.*
6. Biotite Norite, 2 miles E. of Montrose Point. Analyst, G. S. Rogers. Symbol, II. 5. 4. 3. *Hessose.*
7. Biotite Augite Norite, Montrose Point. Analyst, M. S. Munn. J. D. Dana. Amer. Jour. Sci. (3), XXII, 104. Symbol, II. 5. 3. 4. *Andose.*

	1.	2.	3	4.	5	6	7.
SiO_2	73.54	73.32	42.45	54.72	51.49	46.10	55.34
Al_2O_3	15.20	15.01	16.36	17.79	20.72	18.66	16.37
Fe_2O_3	.50	.47	3.20	2.08	1.80	3.00	.77
FeO	.81	1.19	9.85	6.03	7.28	9.58	7.54
MgO	.03	.15	7.92	5.85	3.82	6.71	5.05
CaO	1.69	1.35	9.57	6.84	6.71	8.26	7.51
Na_2O	4.99	4.27	2.61	3.02	3.70	2.57	4.06
K_2O	2.31	3.72	2.29	3.01	2.14	1.59	2.03
H_2O+	.06	.13	.29	....	.31	.18	....
H_2O-	....	....	.16	....	.10	.10	.58
CO_2	....	....	none	....	trace	none	....
TiO_2	.08	.06	4.12	....	2.26	2.88	....
P_2O_5	....	....	.49	....	.15	.70	....
Cl	....	....	....	....	....	.02	....
S	....	....	trace	....	.11	.28	....
Cr_2O_3	....	....	....	....	....	....	....
MnO	trace	trace	....	....	.13	....	.40
BaO	....	....	.19	....	....	trace	....
SrO	....	....	.05	....	....	trace	....
Sum	99.21	99.67	99.55	99.34	100.72	100.57	99.65

MODES.

	1.	2.	3.	4.	5.	6.	7.
Qtz	32.2	32.8	....	....	....	....	....
Orth	8.3	15.6	....	17.8	10.6	5.0	10.0
Albite	41.9	36.2	22.0	25.2	30.9	21.5	34.1
Anorth	8.3	6.7	24.5	26.1	33.4	34.8	20.9
Moscov	4.9	4.8	....	....	....	....	....
Biotite	3.2	4.7	31.8	....	4.6	17.0	5.6
Hnb	....	....	8.4	....	....	2.2	....
Augite	....	....	....	27.2	....	....	11.5
Hypersth	....	....	....	....	13.0	10.2	15.9
Apatite	....	....	1.2	....	....	1.7	....
Titanite	....	....	5.2	....	....	....	....
Mgt	.2	.2	2.6	3.0	1.9	2.6	.7
Ilmen	.2	.2	3.7	....	4.2	5.4	....
Pyrite	....	....	....	....	.4	....	....

NORMS.

	1.	2.	3.	1	5.	6.	7.
Q	32 0	30.5	...	...	...	...	...
C.	1.5	1.5	...	...	5	...	...
or	13.3	21.7	13 3	17.8	12.2	9.5	12.2
ab	41.9	36.2	7.3	25.2	30.9	21.5	34 1
an	8.3	6.7	26.4	26.1	32.5	34.8	20.3
ne	...	...	8.0	...	...	...	...
di	...	...	14.8	6.3	...	5.0	14.0
hy	1.1	2.2	...	20.9	13.8	3 0	11.4
ol	...	...	15.5	...	2.9	15.9	5.3
mt	.7	.7	4.6	3.0	2.6	4.4	1.2
il	...	...	7.6	...	4.2	5.3	...
ap	...	...	.9	...	.4	1.2	...

8. Biotite Augite Norite, 1½ miles S. of Peekskill. Analyst, G. S. Rogers. Symbol, II. 5. 3. 4. *Andose.*
9. Hornblende Norite, ¼ mile N. of Montrose. Analyst, G. S. Rogers. Symbol, II. 5. 4. 3. *Hessose.*
10. Pyroxenite, Montrose Point. Analyst, G. S. Rogers. Symbol, IV. 1^2. 1^2. 2. *Hudsonose.*[50]
11. Olivine Pyroxenite, ½ mile N. of Dickerson Hill. Analyst, G. S. Rogers. Symbol, IV. 1^2. 1^2. 2. *Hudsonose.*[50]
12. Augite Peridotite, Montrose Point. Analyst, W. H. Emerson. G. H. Williams, Amer. Jour. Sci. (3), XXXI, 40. Symbol, IV. 2^2. 1^2. 2. X.
13. Wernerite Schist. Montrose Point. Analyst, G. S. Rogers.

	8.	9.	10.	11.	12.	13.
SiO_2	50 74	45.91	49.95	49.73	47.41	42.96
Al_2O_3	20.30	19 83	6.52	4.01	6.39	19.49
Fe_2O_3	1.23	2.91	1.50	.70	7.06	1.08
FeO	7.27	8.09	10.41	6.66	4.80	4.89
MgO	3.78	5.13	17.02	20.06	15.34	1.50
CaO	7.28	9.32	11.77	16.71	14.32	19 32
Na_2O	3.82	2.78	.98	.63	.69	2.25
K_2O	2.21	1.23	.52	.31	1.40	.26
H_2O+	.31	.40	.65	.39	2.10	1.24
H_2O-	.10	.14	.16	.07	...	06
CO_2	...	.04	25	.26	...	4.85
TiO_2	2.31	2.71	.15	.64	...	1.72
P_2O_5	.15	1.03	none	.02	...	trace
Cl	...	.08	none	...	...	.31
S	.12	.35	.11	.35	.49	.64
Cr_2O_3	...	.01	.10	trace	...	trace
MnO	.13	.07	...	.19	...	.05
CuO	...	...	...	trace	...	...
Sum	99.75	100.03	100.09	100.73	100.00	100.62

[50] The writer ventures to suggest the name *Hudsonose* for this rock, in view of its abundance and typical development in the Cortlandt Series, and inasmuch as *Cortlandtose* has already been assigned to a type apparently not found in the series.

MODES.

	8.	9.	10.	11.	12.	13.
Orth	8.3	5.6	1.7	1.7	8.3	1.7
Albite	32.0	23.1	7 9	5.2	5.2	4.2
Anorth	32.0	36.1	8 3	4.2	7.0	4.2
Biotite	9.9	5 5	5 2	......	......	......
Hnb.	......	7.5	......	......	......	......
Augite	3.2	......	28.1	55 0	45.1	......
Hypersth	8.0	10.0	36.0	10 0	15.9	......
Olivine	......	......	4.7	17.9	9.0	......
Apatite	.4	2.7	......	......	......	......
Mgt.	.9	3.7	1 9	9	7.0	1 6
Ilmen.	4.3	5.1	.3	1.1	......	......
Pyrrhot.	......	.8	.4	.8	......	......
Serpentine	......	......	4.7	2.8	......	......
Calcite	......	......	.6	.6	......	11.0
Meionite	......	......	......	......	......	42.7
Marialite	......	......	......	......	......	11 7
Pyroxene	......	......	......	......	......	11.4
Quartz	......	......	......	......	......	5.4
Titanite	......	......	......	......	......	4.0
Pyrite	......	......	......	......	......	1.4

NORMS.

	8.	9.	10.	11.	12.	13.
or	12.8	7.2	2.8	1.7	8 3	......
ab	32.0	23.1	8.4	5.2	5 2	......
an	32.0	38.1	12.0	7 5	10.6	......
di	2.8	1.4	36.3	59.6	47.9	......
hy	2.8	10.6	19.9	.3	6.7	......
ol	25.9	9.0	15.6	22.6	8.6	......
mt	1.6	4.2	2.3	.9	10.2	......
il	4.3	5.1	.3	1.1	......	......
ap	.4	2.7	......	......	......	......
pr	......	.6	.3	.6	......	......

14. Spinel Emery, high grade, Buckbee Mine. Analyst, G. S. Rogers.
15. Pure Emery, Dalton Mine. Analyst, G. S. Rogers.
16. Feldspathic Emery, Salt Hill. Analyst, G. S. Rogers.
17. Quartz Emery Schist, Salt Hill. Analyst, G. S. Rogers
18. Emery. Analyst, T. Egleston. G. H. Williams, A. J. S. (3), XXXIII, p. 197 (No. 1).
19 *Idem* (No. 4).
20 *Idem* (No. 7).

	14.	15.	16.	17.	18.	19.	20.
SiO_2	1.93[51]	.84[51]	10.60	47.16	....	....	....
Al_2O_3	68.14	59.22	43.72	28.96	31.93	37.43	46.53
Fe_2O_3	1.43	16.66	13.75	6.15	18.19	21.17	32.31
FeO	16.25	14.02	20.11	8.49	....	....	....
MgO	10.02	3.54	8.59	3.80	7.41	7.20	9.43
CaO	trace	trace	.08	2.03	....	....	....
Na_2O	trace	trace	.56	.62	....	....	....
K_2O	trace	trace	.52	.35	....	....	....
H_2O+	1.15	2.65	.85	.77	....	....	....
H_2O-	.12	.05	.07	.10	....	....	....
TiO_2	1.41	3.28	1.43	1.48	1.12	.65	.51
P_2O_5	trace	trace	trace	.02	trace	trace	trace
S	.05	.06	.07	trace	.04	.02	.01
Cr_2O_3	.04	trace	.06	trace	....	....	....
MnO	trace	.06	.10	.05	....	....	....
Magnetic Iron....	....	....	....	....	34.20	19.81	8.98
Siliceous Residue	....	....	....	....	6.42	13.14	2.42
Sum	100.54	100.38	100.51	99.98	99.31	99.42	100.19

MODES.

	14.	15.	16.	17.
Qtz	1.9	.8	3.9	36.7
Orth	....	....	2.8	1.7
Albite	....	....	4.7	4.7
Anorth	....	....	3.9	10.0
Sillimanite.	....	....	....	4.9
Spinel	75.0	21.1	61.3	24.3
Corundum..	19.5	45.2	.9	5.0
Mgt	2.1	24.1	19.7	8.8
Ilmenite ...	2.6	6.2	2.6	2.8

[51] Probably derived in considerable part from the agate mortar.

21. Brown Norite, Buckbee Mine. Analyst, G. S. Rogers. Symbol, IV. 1[1]. 1[1]. 2. *Cookose.*
22. Sillimanite Schist, Dalton Mine. Analyst, G. S. Rogers.
23. Manhattan Schist. Composite analysis of five specimens from various points beyond the borders of the series. Analyst, G. S. Rogers.
24. Manhattan Schist (least altered), Crugers. Analyst, F. L. Nason. G. H. Williams (3), XXXVI, p. 259.
25. Manhattan Schist (nearer contact), Crugers. *Idem.*
26. Manhattan Schist (about 750 feet from contact), Crugers. *Idem.*
27. Manhattan Schist (on contact), Crugers. *Idem.*

	21.	22.	23.	24.	25.	26.	27.
SiO_2	52.27	28 81	57.94	62.98	61.57	55.12	40.16
Al_2O_3	6.81	46.95	21.70	16.88	19.53	24.32	29.50
Fe_2O_3	2.48	10.00	1.57	2.48	5 44	6.13	19.66
FeO	10.01	7.40	5 90	5.00	2.61	4.99	5.80
MgO	23 29	2.08	2.49	1.58	1.90	trace	trace
CaO	2.04	trace	.58	trace	trace	trace	.85
Na_2O	.87	.73	1.74	3.02	3.48	2.71	1.46
K_2O	.25	.27	4 68	7.45	2.14	2.83	1 36
H_2O+	.61	.64	2.17	....	....	....	....
H_2O-	.14	.07	.29	....	....	....	....
CO_2	.13	none	trace	....	....	....	....
TiO_2	.40	2.76	1.01	....	1.53	2.46	....
P_2O_5	trace	none	trace	trace	trace	trace	trace
S	.05	.07	....	.08	.85	1.23	.82
Cr_2O_3	.22	.03	....	....	....	....	....
Mno	trace	.25	.19	....	....	....	....
Sum	99.57	100 06	100.26	99.47	99.05	99.79	99.61

MODES

	21.	22.	23.				
Qtz	....	....	19.2				
Orth	1.1	1.7	5.6				
Albite	7.3	6.3	14.7				
Anorth	10.3	....	2.5				
Muscovite	....	....	38.5				
Biotite	....	....	14.9				
Bronzite	75.4	....	....				
Cordierite	....	17.9	....				
Sillimanite	....	37 3	....				
Corundum	....	15.9	....				
Mgt	3.5	14.4	.7				
Ilmenite	.8	5.1	1.9				

Geology of the Emery

Emery has been mined in this district for the last twenty-two years; and at a previous period, an attempt had been made to use it as an iron ore, but being so high in alumina, when used by itself, it of course hopelessly clogged the furnace which was erected, and the undertaking was abandoned. Since 1889, however, many thousand tons have been taken out for use as an abrasive, although the so-called Peekskill emery is the poorest variety on the market.

Isaac McCoy was the first to mine emery, and on his land, on the central and southern part of the hill east northeast of Pleasantside, is the most pretentious mine in the district. He worked in a small way himself for a while and then leased the property to the Tanite Emery Company of Stroudsburg, Pa., who kept twelve or fifteen men busy at intervals for about eighteen years. The Blue Corundum Mining Company of Boston, Mass., has also done work on his property. The Keystone Emery Company of Frankfort, Pa., started work a little later on the Oscar Dalton property (on the northeast slope of the hill above mentioned) and on the land of John H. Buckbee, which is located on a hill a mile southeast of the last. The work here was later taken over by H. M. Quinn of Philadelphia, Pa. The Tanite Company also leased the land of David Chase, just southwest of Mr. Buckbee's property. The work done on the deposits which are found on Dickerson and Salt Hills is mostly of a private nature, although the Lombard mine was once quite productive; and the same applies to the small pits which are located in the biotite norite area northwest of Crugers.

The work on the emery deposits has been so scattered and irregular that no estimate of the total amount mined can be made. Work is at present going on in the Dalton pits, in a new cut at the McCoy mine (Plate V, fig. 1) and in the southeastern area. A thousand tons or more are lying in the pile at the Dalton property and an equal amount in the emery yard at the Chase mine. The ore is hauled by teams to Peekskill and is thence shipped chiefly to Easton, Pa., as the market demands.

Most of the mining is of a very primitive nature, being chiefly open cutting and stripping; after a small amount of work has been done, the emery usually pinches out. It occurs chiefly in veins and pockets but at the Buckbee mine in fairly well-developed lenses. Here more extensive mining was carried on; tunnels were driven in several places, and a small shaft was sunk, but the timbering has given way, and the whole work has caved in. At the McCoy mine, the largest pit is about 75 feet long by 40 feet wide and is 80 feet deep. The work here was stopped partly on ac-

count of the water, which fills the pit to a depth of about 30 feet. Just at this level, two adits have been run, at either end of the pit; one of these opens a 30-foot pocket of emery, the other merely runs out on the side of the hill. A derrick was used to raise the ore, which was run down to the road on cars. This was the only place at which an attempt was made to use a steam drill, and it proved a nuisance. The usual method consists of enlarging the cracks in the ore by hand drilling, shaking it up with dynamite and extracting it with pick and bar.

Williams was the only geologist to discuss the emery in any detail; Dana[52] only briefly mentions it, since in his time it had not been mined except for iron. He notes the thin magnetite beds in diorite on Crugers Point, which Williams has shown to be merely metamorphosed inclusions of schist,[53] and states that the ore is chloritic, whereas Williams[54] has shown in his discussion of the emery that the green mineral is pleonaste.

The latter, in his first description, states that the veins are segregations in the norite. He describes the ore from a microscopical standpoint, mentioning the various minerals which the present writer describes below; and gives seven analyses of the emery, partly chemical and partly physical, but makes no mention of the localities from which the specimens were taken, or what varieties they were, etc. In his paper on contact metamorphism, however, he abandons his former view. To quote:[55] "The isolated inclusions (*i. e.*, the metamorphosed schist inclusions at Crugers) of spinel and corundum are almost identical with the more extensive deposits of the same character occurring near the southern border of the norite region farther to the east and described at length in a former paper. Their origin in both cases is without doubt essentially the same."

It is somewhat unfortunate that his previous view, based on fewer observations, should have found its way into the literature.

J. H. Pratt[56] gives a condensed account of Dana's work and of Williams's work on the norites and evidently relies largely on the latter for his statement that the emery is probably due to segregation in the norite along the borders of the magma, in a fashion analogous to that of pyrrhotite, etc. The fact which sustains this view is given as the "gradual transition of the spinel, iron ore and emery into the normal norite"—a fact observed by Williams. He does not appear to have consulted Williams's other papers; but from the description of the series given above,

[52] Amer. Jour. Sci., (3), XX, 199-200. 1880.
[53] Amer. Jour. Sci., (3), XXXVI, 261 *et seq.* 1888.
[54] Amer. Jour. Sci., (3), XXXIII, 194-199. 1887.
[55] *Loc. cit.*
[56] Corundum and its Occurrence and Distribution in the United States, Bull. 269, U. S. G. S., pp. 41, 93 and 137. 1906.

it is evident that no broad deductions can safely be made from the study of one member, aside from the fact that in only one place does the ore occur in a norite area. F. W. Clarke[57] quotes Williams as regarding the ore as a segregation, as does also J. F. Kemp.[58] Lagorio,[59] however, refers to the deposits as in contacts, although his reference is to Williams's first paper.

PETROGRAPHY OF THE EMERY AND ASSOCIATED ROCKS

Perhaps the description of the several types of occurrence may be facilitated if the ore and some of the rocks peculiar to the mines are considered first.

Spinel Emery

In the hand specimen, spinel emery is a heavy black fine grained aggregate, with dark gray crystals of corundum appearing in the best varieties; sometimes the corundum is pink (approaching ruby) and sometimes blue (approaching sapphire). Unless these crystals are large, however, the amount of the mineral present cannot be distinguished. The emery often has an excellent fracture and closely resembles the Turkish emery. In thin section, it is seen to consist of an aggregate of pleonaste, corundum and magnetite. The pleonaste, except in the highest grade of ore, constitutes the bulk of the rock. It is in rich green grains of irregular shape, closely crowded. They are, of course, isotropic and have a high index of refraction, though the surface appears smooth. They often carry magnetite inclusions in the form of very fine parallel rods. The corundum is present in all amounts; it may constitute half the specimen, or it may be lacking entirely. The grains, which may occasionally reach an inch in size, are in this variety colorless in thin section. They exhibit a prismatic shape, which is usually quite sharp and apparently always crystallize before the spinel. They are always strongly cracked and are often con-

Fig. 4. *Relations of Spinel, Corundum and Magnetite in Emery. Sl. 326*

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[57] Data of Geochemistry, Bull. 330, U. S. G. S., p. 278. 1908.
[58] Ore Deposits of the U. S. and Canada, pp. 61 and 173. 1906.
[59] Zeit. Kryst. Mineral, vol. 24, p. 288. 1894-95.

siderably altered to a hydrated mica (damourite or margarite), so that their double refraction is destroyed. They give the usual tests. The magnetite is in somewhat smaller grains scattered among the spinels, and it is usually not nearly so abundant. It seems to have crystallized simultaneously with the corundum (fig. 4).

Williams mentions an analysis of the spinel "whose results were unfortunately lost," but from the fact that the analyst remembered that the MgO ran only about 9 per cent., he concluded that the mineral closely approached the ferrous aluminate, hercynite. In the analyses (Nos. 14 and 16) of the emery, made by the writer and given above, the spinel was chemically separated from the magnetite and ilmenite, and the analysis of the mineral as recast gave the following results:

	(14)	(16)
Al_2O_3	64.86	65.19
FeO	21.78	20.78
MgO	13.36	14.03

From the analyses of pleonaste given in Dana's Mineralogy, there appears to be no reason for doubting that the spinel in question is of this variety, and not a hercynite.

Pure Emery

Pure emery, which has a peculiar reddish black tint, is rare. It has the fracture and other characteristics of the other variety, but no corundum can be distinguished. In thin section, however, it appears that corundum is the chief constituent. It occurs in small square grains which contain reddish brown inclusions in great abundance. These may completely fill the center of the crystal, or they may form a ring, as is often observed in leucite. They are probably ilmenite. The corundum is badly altered in this rock, as shown by the high percentage (2.65) of water in the subjoined analysis. The magnetite constitutes about one third of the rock. Spinel rarely occurs; biotite has been noticed in small amount.

Feldspathic Emery

Feldspathic emery resembles the spinel variety when well developed; and a surprising amount of feldspar may be present without being noticeable in the hand specimen. Streaks of almost pure magnetite may occur in this ore, which was the one formerly mined for iron. In thin section, the plagioclase is seen to make up from one third to one half of the rock. It is usually basic, though not always. The corundum is scat-

tered through the rock, usually associated with the more basic minerals; it is generally of the typical colorless variety, occurring in medium-sized idiomorphic crystals. In ore from certain places, however, the corundum is deep bluish green in color, resembling glaucophane, with strong pleochroism: E light greenish yellow, and O dark greenish blue. It then occurs in stouter crystals, with less distinct outline. Once recognized as corundum, it is always unmistakable. Spinel is typical and abundant, as is also magnetite. Sillimanite, in long blades and in a confused fibrous mass (fibrolite), is often present.

Quartz-Emery Schist

Quartz-emery schist is most closely associated with the last variety, which grades into it; it is also, however, found in the spinel emery mines. It is usually consigned to the dump as too poor in emery. Quartz streaks run through it in great abundance and give it a distinctly gneissoid appearance, and it was this resemblance to a schist or gneiss which first suggested (to Dr. Berkey and the writer independently) that it might possibly be an altered inclusion. This texture is brought out to a certain degree in the accompanying photograph of a typical hand specimen (Plate V, fig. 2). It is much like the feldspathic emery under the microscope, differing chiefly in the abundance of quartz. This is in large interlocking grains, and it may compose one third or more of the rock. It sometimes carries an abundance of rutile inclusions in sharp yellowish needles. The corundum in this rock is often of the peculiar variety described under the last; and the rock may (at the Buckbee mine for example) become very sillimanitic.

Besides these distinct varieties of ore, corundum or spinel, or both, may occur in the wall rocks, such as diorite, norite, etc. In these rocks, the corundum is usually in more irregular crystals, and the common colorless variety may show pleochroic blotches of an ultramarine blue.

Norite Proper

While norite proper must bear the same name as that given the more widely spread variety, it is in reality a somewhat different rock. In the hand specimen, it usually is of a soft brownish color, being apparently composed of enstatite and feldspar, with the former generally in excess. The rock is perfectly massive. In thin section, the dark mineral is seen to be orthorhombic pyroxene of a peculiar type. It is usually more or less idiomorphic, occurring in rounded oblong crystals, a habit not seen in typical norite. The pleochroism is weak (X yellowish pink, Z grayish

green), giving the mineral a curious washed-out appearance. The analysis shows it to contain 11.5 per cent. of FeO, so that it is bronzite. It may become very abundant, so that the rock is almost a bronzitite, which was never noticed in the typical norite proper; and magnetite, moreover, is almost lacking. The writer has three slides containing the contact of this rock with spinel emery. In every case, the feldspar is continuous over the line; in two the spinel and magnetite are sharply segregated from the norite, while in the other the minerals mingle for the space of about 1 mm. The feldspar of the emery is somewhat serictized, and its amount is surprising, considering the black heavy aspect of the ore. In one of the slides, a line of spinels diverged from the main mass and ran out over the norite, crossing the bronzites indiscriminately.

Sillimanite Schist

Sillimanite schist is usually light gray in the specimen and of a fine, somewhat fibrous texture. The blades of sillimanite, however, can generally be distinguished, and they sometimes reach one half an inch in length, or rarely an inch or more. This rock is extremely tough and so hard that it will turn a drill at times. The "ore" from the Dalton property and from the latest cutting of the McCoy mine is largely this rock, although it is a poor abrasive, powdering when ground.[60] Under the microscope in typical cases, it is seen to be made up chiefly of sillimanite. This is largely fibrolite, with the blades scattered more or less abundantly through it. These latter are blotched with a fine brown dust in places, and they also carry abundant magnetite inclusions. Cordierite is almost always present in varying amount; its biaxial figure and the strongly pleochroic yellow halos which surround its inclusions serve to distinguish it from quartz. Allanite, in large brownish prismatic crystals, is often present. It shows parallel extinction and good pleochroism from yellowish brown to greenish brown, but the color, pleochroism and birefringence often vary even in one

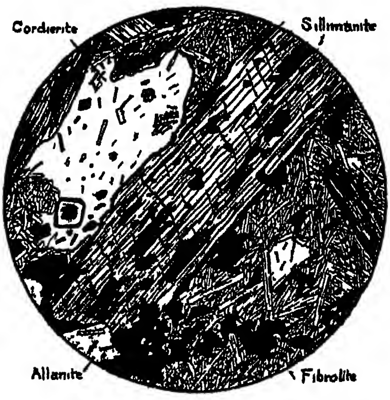

Fig. 5. *Sillimanite Schist. Sl.* 304

[60] Mr. John H. Buckbee rather aptly characterized this rock to the writer as being from a practical standpoint, "like gristle,—neither bone nor meat."

crystal. Corundum, in any of the three varieties, may be present, and garnet (almandite) has been observed. Quartz was found in one instance. Magnetite and ilmenite are usually abundant.

In the rock just described, the important minerals are of a peculiar type, but the relation of this abnormal schist to true igneous rocks is indicated by the fact that it often contains hornblende, biotite, hypersthene and even feldspar, chiefly orthoclase. In fact, a pure sillimanite schist is more rare than one containing a little biotite or hornblende, and in two cases a hornblende pyroxenite was found which carried merely subordinate amounts of the sillimanite and its associates.

Other rocks are found associated with the ore, such as quartz gabbro; etc., which have not been before considered, but their peculiarities are indicated by the names given. The statement that shearing is often apparent at the mines may be recalled in this connection; in several cases the writer mistook for mica schist rocks which appeared under the microscope to be diorite and norite, and the schistosity was so striking that he was led to record the dip and strike. Faulting has also often been seen, and the ore itself is always at least cracked.

TYPES OF OCCURRENCE

Gradational Type

In the area of biotite norite which lies northwest of Crugers, a number of small emery pits have been sunk. The ore seems to be widely developed in this district, but the veins are all small and rapidly pinch out. The ore is of the spinel emery type; it is sometimes in sharp veins, but more often it grades into the quartz-emery schist.

The small pit which offers the best opportunity for study lies 250 feet due south of the point at which the mica schist inclusion outcrops on the post-road. In this pit, an unmistakable quartz emery schist with streaks of coarse red garnet lies to the north, *i. e.*, nearest the schist inclusion; it is adjoined on the south by the remnants of the ore, about two feet in width. This ends abruptly as far as could be ascertained in the field; but specimens of the adjoining rock taken one, two and four feet from the contact were respectively spinel norite with garnet, spinel norite and norite. This rock was of the ordinary variety described on page 30, with the spinels merely superposed upon it. This gradation appears to be the typical association of the emery in this district, although the cuttings are not confined to this distance from the large schist inclusion. The ore is important chiefly from a theoretical standpoint; only a very limited amount has been taken out.

Emery Schist Type

Emery schist is a very common type in the southeastern part of the Cortlandt area, in the Dickerson and Salt Hill region. The country had here been widely prospected for iron at the time when it was thought that the ore was magnetite. The emery has been mined on the roadside, at the southeast corner of Salt Hill; and it is said to run more or less continuously over the mountain to the north. Here it appears to trend more to the east, being mined in several places on the eastern slope of Dickerson Hill. This seems to be the chief vein, but there are several other outcrops, some of which are along the border of the district to the west and east.

In all of the outcrops visited by the writer, the ore is of the same type; a vein of black emery (which in thin section is seen to be the feldspathic variety) is bordered on either side by the quartz emery schist. More often, perhaps, no distinction can be made between the two; the emery merely becomes quartzose in streaks. Bands of pure quartz a foot or more across are not uncommon. The quartz streaks are not always straight; they are often strongly contorted and crumpled. The opening on the road above referred to is within a hundred feet of the border of the series, and possibly less; and so closely does the emery in all but color resemble a coarse schist, that it was difficult to decide on its identity offhand. To the north of this, about a quarter of a mile, is a small inclusion of mica schist, strike N. 20° E. 80° E.; and 75 yards south of this outcrop, emery is again taken out. The strike of this inclusion is very close to the general strike of the schist in this district and also of the emery schist. The latter varies from N. 35° E. to N. 60° E., but it generally approximates the former. On the west side of Salt Hill, ore was found in a tongue of pyroxenite which seemed to be projecting directly into another inclusion of schist.

The ore of this type, therefore, is sometimes on the border of the series, near the contact with the mica schist, sometimes near an inclusion of the same in the igneous rocks, while again, although it shows exactly the same structure, no association with schist was observed.

Norite Type

Norite and the following type are found chiefly in the northeastern area, where all of the larger workings are located; but in this area, the emery is always associated with this peculiar variety of norite, or else as is indicated below under the following type. The succession and rela-

tions of the various rocks are, however, much more complicated than in the previous types, and three varieties may be distinguished.

In one of the Dalton pits, a simple succession from the brown norite to ore to sillimanite schist was observed. The former is typical; the latter is coarser than usual, carries some garnet and sometimes shows crumpling and contortion. The ore varies in width from two to ten feet and is of the pure variety.

At the Buckbee mine, the underground work is inaccessible, having all caved; there are two open cuts, however, which seem to indicate the structure. These are both lenticular in ground plan, curving into the hill and out again. The ore is an excellent one, being often nearly half corundum in large gray-brown crystals, and practically fresh and unaltered. It may at times carry garnet and occasionally pyrite in half inch crystals. In both of these pits, the wall rock is the brown norite, which in this case, however, resembles ordinary norite, in thin section, more closely. It is altered to chlorite in patches. Such of the ore as has not been taken out occurs in this rock in irregular veins, which often "break" into pockets. The poorest grades of ore resemble the streaky quartzose emery, but this in thin section resolves itself into a quartz sillimanite schist, often garnetiferous. There is a broad irregular band of coarse pyroxenite running horizontally through the cliff of brown norite, but it seems to be a local segregation, having nothing to do with the ore. A vogesite dike appears in both of the pits. The succession here may or may not be as in the gradational type; it would seem rather that the sillimanite schist encloses the ore and is itself surrounded by the norite.

In the two other large pits on the Dalton property, a more complicated relation exists. The wall rock is a quartz gabbro; this becomes a much chloritized pyroxenite of the usual type, which passes into brown norite. The latter is at first chiefly hypersthene, but it becomes feldspathic near the ore, which is of the pure variety. Sillimanite schist is plentiful; in one case, it occurs in irregular fine-grained masses on the other side of the ore, while in the second case, it seems to occur mingled with the ore. Essentially the same succession is to be observed in the latest cut of the McCoy mine. This is about 30 feet wide by 45 feet deep, and 35 feet high and gives the complete cross section. At a short distance away, the whole ledge resembles a sandstone with vertical dip, owing to the regular zones in which the types occur (Plate V, fig. 1). Starting from the west, the succession is biotite norite (typical), sillimanite schist, "ore" (sillimanite schist with spinel, very fissile, or "slatey" as the miners call it), then the typical sillimanite schist again; this succession

is then repeated on a smaller scale, with an exceptionally fine grained biotite norite. This is evidently an apophysis of the larger mass projecting into the schist. On the east, the wall rock is a hornblende pyroxenite, which seems to be the real country.

Micaceous Type

Two of the three larger pits of the McCoy mine and most of the smaller prospects scattered over the hill are of micaceous type, in which a sheared micaceous rock is associated with the ore. The ore from the large pit of the mine, and the chamber connected with it (described above), was the best mined anywhere in the district, except possibly Buckbee's. Small areas of pink and blue corundum emery were found in this pit. In the other pits, it is a lower grade of spinel emery, seldom showing the corundum crystals.

In the large pit, which is about 80 feet deep, of which depth 30 feet is below water, the sides are not quite vertical, dipping 70°–85° S. This is most apparent at the eastern end, where the wall rock is very micaceous, dipping as above and striking N. 80° E. At times, it strongly resembles Manhattan schist; again, the mica may be all biotite, and the feldspar may diminish until the rock is practically an aggregate of andesine, with less orthoclase and a great amount of biotite. Scattered through these minerals is abundant spinel, with varying amounts of corundum. At the west end of the pit, the wall rock is diorite, with strongly pleochroic hornblende, which is in idiomorphic crystals often absorbed and embayed and considerably in excess of the biotite. To the east and south of the mica rock lies a pyroxenite, carrying hornblende and some biotite; and it may also contain sillimanite and garnet. The large veins of ore, if not worked out, are below water level and inaccessible; but the mica rock carries small veins of spinel emery. Men who had worked this pit stated that the ore was always found in this black mica rock, often associated with garnets; that occasionally white mica was found with it, and that in the ore itself would sometimes be found little bunches of black mica or green mica (clinochlore ?). On the dump, a large amount of the quartzose-streaked emery was found, but it was not observed in place.

About 50 feet to the east of this pit is the head of a cut extending 300 feet east. It is 30 to 60 feet wide, becoming at its head 50 feet deep The wall rock on either side is a typical looking diorite, as in the large pit. Then, starting from the diorite, comes a rock which entirely resembles a mica schist (N. 80°–90° E., 75°–90° S.), but which proves in thin

section to be a biotite norite carrying abundant spinel and some corundum. Adjoining it is a poor ore, which is a sillimanite schist with abundant cordierite. Then comes a brown norite, which is followed by a good spinel emery; and hornblende pyroxenite separates this from the diorite. This is, however, an ideal cross-section, found only in one place; in other places, the succession is less regular and often repeats itself. In a 40-foot cut to the northeast, the structure is exactly the same, except that the spinel norite is replaced by spinel diorite, as in the large pit, and that the brown norite is lacking.

In these three pits of the McCoy mine, then, the ore occurs in a schistose, spinel-bearing micaceous rock, either diorite or norite, and is associated with sillimanite schist and hornblende pyroxenite.

The Chase mine, which is the last to be described, appears to be similar in structure to these; but garnets in great abundance are found there. The ore occurs in a ledge, flanked on one side by a corundum-bearing sillimanite schist, which at times becomes very coarse; and on the other by a very biotitic rock, similar to that in the large pit of the McCoy mine, except that it carries corundum in irregular masses instead of spinel. In irregular association with the ore occurs a feldspathic rock containing abundant garnets. From a rotten zone in this rock, well-formed trapezohedrons one and a half inches in diameter can be readily extracted. This rock in thin section is seen to be chiefly a basic altered feldspar, with a little biotite, spinel and corundum and the large garnets. It may occur in the ore in irregular masses, but is chiefly separate. In the ore itself, garnet occurs abundantly, both as crystals and as rounded flow-like masses, often four or five inches across. The ore is somewhat peculiar aside from this, being more than half corundum in fairly fresh white crystals; for the rest, it is made up of spinel, magnetite, allanite and garnet. This is a high grade ore, but it is injured by the abundance of brittle garnet and allanite. Around the cutting for a few hundred feet, a very garnetiferous rock extends, whose dark mineral is probably an altered hornblende, constituting a diorite. The true country rock is, however, a pyroxenite, which varies an indicated on the map.

The foregoing description of the emery deposits may be epitomized as follows:

1. The ore usually occurs in a region in which mica schist inclusions are abundant and often within a hundred feet or so of such an inclusion; and the largest mines (McCoy, Dalton, etc.) are within 1000 feet of the border of the Cortlandt Series.

2. The ore is always in sharply defined veins, pockets or lenses, but its constituents often occur disseminated through the rocks immediately adjacent.

3. The ore is immediately associated with abnormal rocks, containing sillimanite, cordierite, garnet, quartz or allanite, which are found nowhere else in the area, except around certain schist inclusions near Crugers; or more rarely, it adjoins rocks which are normal except for the spinel scattered through them. There is often a great abundance of biotite around the ore, which is also characteristic of these inclusions.

4. These rocks often exhibit evidences of shearing, faulting and cracking, which is rare in other parts of the district, except around schist inclusions.

ORIGIN

In reviewing the possible modes of origin of the emery in the Cortlandt Series, it appears evident that only two are plausible; the emery may be pyrogenic, due to magmatic segregation, or due to the absorption of some of the numerous schist inclusions in the area. The evidence may perhaps be more effectively weighed if we first briefly consider the artificial production of corundum and its occurrence in other districts.

Artificial Production of Corundum

Several French geologists have been especially active in the field of synthetic mineralogy,[61] but their results in this connection are of little importance. Many of them worked with alumina and artificial salts, so that their processes find no equivalent in nature; others dissolved alumina in various melted minerals, adding in some cases a trace of ammonium fluoride or some similar salt. These last experiments are of more importance in a geological way, but they appear to have no application to the Cortlandt Series.

The only relevant case that the writer has been able to find of the production of corundum by the simple fusion of a mineral is described by Vernadsky.[62] He observed the formation of corundum and sillimanite in a melt of muscovite, in the course of his experiments on the genesis of sillimanite.[63]

Probably the most important investigation from a geological point of view is that undertaken by J. Morozewicz.[64] Basing his work on the

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[61] FOUQUÉ and LÉVY. Synthese des Minéraux et des Roches, Paris. 1882. See also L. BOURGEOIS, "Reproduction artificielle des minéraux," in Fremy's Encyclopédie chimique, II, pt. 3, p. 63.

[62] On the Sillimanite Group, and the Role of Alumina in Silicates. Moscow, p. 83. 1891. (Russian.) He also describes the formation of sillimanite from clay in "Sur la reproduction de la Sillimanite," Bull. Soc. franç. de minéral., p. 256. 1890.

[63] Corundum is commercially manufactured by the Norton Emery Company at Niagara Falls by the fusion of bauxite, previously rendered anhydrous by thorough heating.

[64] "Experiment. Untersuchungen über d. Bildung d. Mineralien im Magma." Tschermak's mineral. und petrog. Mittheil., XVIII, pp. 1-90 and 105-240. 1898.

principles of Vogt and Lagorio, he rejected the French synthetic methods as unnatural and studied the deposition of corundum in the melts of a large glass factory, where he could control his temperatures up to 2100° C. His melts varied in size up to one hundred pounds or more. They were made up, sometimes of the pure salts and sometimes of powdered minerals, to approximate the composition of certain natural eruptive rocks. They were contained in clay crucibles, whose position in the furnace might be varied according to the degree of heat desired. A point often overlooked in connection with this investigation, and one which he states to be its most serious defect,[65] is that 30 per cent. of his melts were spoiled because they attacked the clay crucibles. Melts high in magnesia with low alumina and alkalis, were especially prone to this, deriving alumina from the crucible to form spinel, while those rich in lime, alumina and alkalis had no effect at the highest heat. The results of this well-known study prove that the role of alumina in a magma is entirely analogous to that of silica; if it be saturated with respect to alumina, corundum will separate out just as quartz does in a granite. An alumino-silicate magma is saturated when it has the general composition MeO, m Al_2O_3, n SiO_2 ($Me = K_2$, Na_2, Ca, and $n = 2 - 13$) and m is more than one. If silica is also in excess (over 13), sillimanite is formed. If magnesia and iron are present in excess, they will form spinel; or if silica is also in excess, cordierite will separate. The separation of corundum from a magma, therefore, is governed by definite laws; and minerals, moreover, which have previously been thought of as due to contact action are thus shown to be pyrogenic under certain conditions.

Morozewicz in a previous paper[66] had shown that alumina will readily dissolve in a molten magma whose composition approximates that of basic magnesian rocks, and that on cooling, the excess alumina separates out as corundum and spinel.

Corundum may, therefore, be formed by the action of "agents minéralisateurs" on alumina, or by the fusion of certain aluminous minerals, or by the solution of alumina to supersaturation in molten magmas.

Origin of Corundum in Other Localities

Since the emery of the Cortlandt Series is always in igneous rock, only a few similar occurrences of corundum in other localities will be noticed.[67]

[65] *Op. cit.*, p. 18.
[66] Zeitsch. fur Krystall., XXIV, 281. 1895. See also Lagorio, *idem.* p. 285.
[67] For a full discussion, see J. H. Pratt, Bull. 269, U. S. G. S., pp. 71-96. 1906.

Corundum is found in North Carolina in peridotite segregated at the contact of the igneous rock with gneiss. There is a sharp contact with the gneiss, but the corundum grades into the peridotite. Pratt[68] believes that it separated out of the magma as an original constituent, according to the laws cited above, and segregated at the border in a fashion analogous to that of pyrrhotite or ilmenite. The earlier writers,[69] however, believe that it is due to contact action on the gneiss. Corundum is also found in plumasite in Plumas County, California, and there is no doubt that it is an original pyrogenic constituent.[70]

Corundum has been found on the contact of granite and clay slate on Dartmoor in Devonshire, apparently due to contact action,[71] and at contacts between granite and micaceous quartzite near Morlaix, France, having the same origin and associated with sillimanite and andalusite, spinel, etc.[72]

Corundum in sapphire crystals has been found in a monchiquite dike at Yogo, Montana. The rock is too low in alumina, however, for it to have separated out as an original constituent, and it is probably due to inclusions of argillaceous sediment derived from the underlying rocks.[73] Corundum and zircon found in basalt and other basic rocks in Haute Loire[74] are thought also to be due to the destruction of gneiss inclusions.

Corundum, then, in igneous rocks, may be due to magmatic segregation, or to contact action, or to the absorption of aluminous inclusions.

Evidence as to Its Formation in the Cortlandt Series

It has been shown above that the emery in the Cortlandt Series is often streaky in appearance; usually associated with inclusions of mica schist or found near the borders of the area but not on them; immediately associated with sillimanite rocks and other abnormal varieties; showing no marked preference for any country rock as previously supposed, though found most generally in pyroxenite, and often associated with rocks which have undergone metamorphic action. Spinel and corundum may be scattered through the adjoining rocks for a few yards or less whether it be an abnormal rock or a normal igneous flow.

[68] *Idem*, p. 81.

[69] See for example T. M. Chatard, Bull. 42, U. S. G. S., p. 45. 1887.

[70] Bull. 269, U. S. G. S., p. 94. 1906.

[71] K. Busz, Geol. Mag., p. 492. 1896.

[72] A. K. Coomára-Swámy, Quart. Jour. Geol. Soc., LVII, 185. 1901.

[73] L. V. Pirsson, "Petrography of the Igneous Rocks of the Little Belt Mountains," Montana, 20th Ann. Rep. U. S. G. S., pt. 3, p. 554. 1900.

[74] A. Lacroix, "Sur l'origine du zircon et du corindon de la Haute Loire," Bull. Soc. franç. de minéral., p. 100. 1890.

The Theory of Magmatic Segregation

That magmatic segregation is possible is proved by the experiments of Morozewicz, who has shown that corundum may separate out of a supersaturated magma and that the associated minerals, which were formerly supposed to be due in every case to contact action, may have a similar origin. If it has so formed, we should expect it to show probably a close association with the border of the igneous area, as in the case of the Carolina peridotite, since such an abundance of early-crystallizing minerals would be carried to the borders by convection currents, or by some process akin to Soret's principle. It shows a rather close association, in some cases occurring practically on the border, while the most important mine is located within a thousand feet of it. Other occurrences are, however, a mile or more removed. The ore is disseminated to a certain degree through the surrounding rocks, which are sometimes otherwise normal and sometimes extraordinary aggregates of the minerals which have been shown to be associated with pyrogenic corundum under certain conditions. Moreover, the magnetite which is associated so plentifully with the ore is known to be in other localities a basic segregation,[75] although in such cases it is usually highly titaniferous. It is possible, therefore, that the ore has separated out of the magma as an original pyrogenic constituent.

There are certain phenomena, however, which this hypothesis does not account for. If the emery shows any preference for the borders, as in the case of the Carolina peridotite, it should show a distinct preference, occurring directly on the borders as a sharp contact but grading into the igneous rock. In no case, however, was it observed directly on the border or even on the margin of an inclusion. Moreover, in none of the cases of pyrogenic corundum cited by either Morozewicz[76] or Lagorio[77] is magnetite a very important constituent; certainly in none does it occur in excess of the corundum. Basic segregations of magnetite, furthermore, are usually very titaniferous,[78] while in the Cortlandt Series, the average of TiO_2 in the four different emery analyses is 1.90 per cent, while in seven analyses of the important igneous rocks of the district, the average is 2.15 per cent., running much the lowest in the pyroxenites. Nor does this theory explain the dynamic action which is so evident at the mines and almost confined to them; nor the streaked appearance of the ore in a very

[75] See for a summary Kemp's Ore Deposits of the U. S., p. 171, etc. 1906.

[76] Min. pet. Mitth., XVIII, 212-219. 1898.

[77] Zeit. Kryst. Min., XXIV, 285. 1895.

[78] Thus, for example, the ore from the classic locality for this process, Taberg, is almost an ilmenite; similarly the Cumberlandite of Rhode Island, the titaniferous magnetites of the Adirondacks, etc.

important variety, unless indeed flowage after the separation of the emery is postulated. Finally, the abundant garnets found at the Chase mine are not explained, nor the biotite at the McCoy and Chase mines; nor is the association of the emery with quartz accounted for. It would be difficult to explain how corundum could separate in the presence of quartz, since according to Morozewicz the two would combine to form sillimanite.

Theory of the Absorption of Sedimentary Material

The possibility of the effectiveness of the absorption of sedimentary material is evidenced by the fact cited above from Morozewicz, viz., clay crucibles are attacked at a high temperature by melts rich in MgO and poor in Al_2O_3 and alkalis, such as pyroxenite. If this could take place at 2100° C. with a low pressure, it appears certain that a molten magma of such composition could readily attack a more or less attenuated inclusion of mica schist; and the abundance of these inclusions in the district has already been shown.[79] Lacroix,[80] moreover, states the following general rule: "Si l'enclave diffère beaucoup de la roche eruptive par sa teneur en silice, elle est facilement detruite et l'on n'en trouve plus, en général, que des traces." This principle had been applied by him in Haute Loire and by Pirsson at Yogo, Montana.

In such a case, the process would involve the separation of a small mass of aluminous sediment and its more or less complete absorption by the subterranean magma. This would give rise to a local enrichment in alumina, which would then be deposited according to the laws enunciated by Morozewicz. The theory thus involves certain features of both magmatic segregation and contact action, but it is essentially neither; nor does it involve the old view which Morozewicz and Lagorio have shown to be false, that corundum is infusible in a magma and that it merely represents the unattacked portions of the xenolith. The occurrence is taken by the writer to be a strong confirmation of the laboratory experiments of these geologists, rather than to oppose them.

The accompanying analysis of mica schist was made with a view to determining the extent to which this rock could have contributed alumina. The percentage found (21.70) is only slightly above that in the norites; pure norite (which is chiefly feldspar) reaches 20.72 per cent., being the highest. The pyroxenites in which the ore is generally found run about

[79] In this connection, also, the limestone inclusions of the district, altered to lime pyroxenite in one case, wernerite schist in another and a garnet-tremolite rock in a third, may be recalled as indicating the capability of the igneous rock to absorb and work over an included mass. The fact that most of the inclusions of schist practically lack mica, which must have been absorbed by the magma, may also be recalled.

[80] *Op. cit.*, p. 101.

four to six per cent. The specimens of schist analyzed had undergone little or no contact action; but it will be recalled that at Crugers, for example, the schist shows a steady increase in alumina as the igneous rock is approached, until on the contact the per cent. is 29.50, as shown by Williams's analyses. The same, moreover, holds with regard to iron; the unaffected schist runs 7 or 8 per cent., but at the contact shows 25 per cent. Even at a point 700 yards from the contact, the schist runs 24.32 per cent. in Al_2O_3 and 11.12 per cent. FeO and Fe_2O_3. The reason[81] for this increase is a question beyond the province of this paper; the fact remains that the mica schist in contact with the igneous rock is abundantly able to contribute alumina and iron and that even the unaltered schist is much higher in alumina than the most common country rock of the emery. The silica of the schist presumably goes to form the quartz streaks so generally found with the emery. That the emery may be formed by the absorption of schist is also indicated by its occurrences in the cliff of diorite at Crugers. As described above, every gradation, from the unaltered mica schist to one composed chiefly of quartz, biotite, magnetite, sillimanite, garnet, etc., at the contact and so to the inclusions in the igneous rock itself, composed of magnetite, spinel and corundum, may be traced. These thin lenses of magnetite and spinel are so completely changed that they were once mined for iron. Moreover, pleonaste was found in the garnet rock from the contact at Salt Hill; and it was found in one case in an igneous dike cutting limestone.

The sillimanite, etc., with which the emery is associated, may, according to Morozewicz, be found when the ore is pyrogenic, although N. H. and A. N. Winchell state that sillimanite "in igneous rocks occurs only as a result of absorption of foreign material."[82] It is at least certain that it occurs abundantly on the borders of the district, where it can only be due to contact action. Garnet, which is also found as a reaction mineral, is a similar case. The great abundance of biotite in some of the mines is paralleled by its abundance at the Crugers contact, and the green mica which is said to occur sometimes in the emery is also found by Williams in certain inclusions and identified by him as margarite. Quartz is common on the contact and also constitutes the bulk of some of the inclusions at Crugers; its association with the emery is thus paralleled, whereas it is apparently not known in association with true pyrogenic corundum.

If this theory be correct, anything like a sharp contact of the emery or its associates with the mica schist would not be expected, nor, in fact,

[81] There seems to be no warrant for thinking that the igneous rock could have contributed this iron and alumina, as is often the case in garnet zones in limestone.

[82] Optical Mineralogy, N. Y., p. 363. 1909.

would the mineral be looked for directly on the contact. It is evident that if the emery is the result of the absorption of the schist, larger masses of the latter might be looked for in the neighborhood, but if the inclusion were small and therefore easily assimilated, they would, of course, not be found. Thus, in some cases we find inclusions of schist near the emery, but never to the writer's knowledge nearer than 200 feet; and often they are lacking.

The resemblance of the Salt Hill types of ore to a black quartzose schist has already been remarked upon, and the rough approximation of its strike to that of the schist has also been noticed. In the light of the foregoing facts, it would appear that these occurrences are merely partially assimilated inclusions of schist entirely analogous to those so well exposed at Crugers; whereas when the schist is quite absorbed, a much more complex aggregation of minerals results, containing no quartz except in a similar streaky mass at the borders. In the case of the emery pit in the biotite norite area north of Crugers, where the spinel grades into the surrounding rock, this gradation may be thought of as a quick lessening of the effects produced by the absorption of the schist, *i. e.*, the enrichment in alumina is naturally merely a local development, although at the same time it can have nothing like a sharp contact. This same statement, of course, applies to similar cases at the other mines. Reference to Morozewicz's paper, summarized above, will furnish the conditions under which the several minerals must have formed.

It must not be supposed, however, that anything like a simple direct linear variation exists between the schist and any of the igneous rocks; a segregational process of some kind must be postulated, for even a richly aluminous schist could not form as a direct hybrid a rock carrying the 59 per cent. of Al_2O_3 found in the richest emery. Or, since at times the schist retains something of its form and is evidently not entirely absorbed, it may be supposed that the hybrid formed contains the schist constituents in greater quantity than those of the igneous rock. The variation diagram as constructed between mica schist and quartz emery schist and a typical norite shows a distinct approach to linear variation, but if pyroxenite be used instead of norite, the curves are often sharp; and it is evident that more analyses must be made before the crude process outlined above can be reduced to an exact determination.

The final point to be considered—the dynamic action at the mines—is one whose significance is not clear. The fact remains that similar effects are common, though not universal, around the schist inclusions of the district, thus emphasizing a further similarity. It was suggested above by the writer that it might be due to shearing along zones of weakness in

the area, which would naturally occur chiefly along the borders of foreign inclusions and conceivably in places where these inclusions had been absorbed. In the case of the mines, it is also possible that the schistose rock is an altered inclusion of the schist itself; but the entire absence of quartz and muscovite and the presence at times of such minerals as hypersthene tend to refute this view. Finally, it is possible that these rocks may be inclusions of Highland gneiss; but if they were, their action on the igneous rocks would be undoubtedly similar to that of the schist, and, moreover, their associations indicate that they are not foreign masses.

This completes what the writer has to say concerning the origin of the emery. From the points brought out, it is evident that the ore has in most cases at least been formed by the action of the igneous rock upon included material, thus giving rise to a magma supersaturated with respect to iron and alumina; and out of this the corundum and its associates crystallized according to the laws formulated by Morozewicz. The evidence, while sufficient to justify a fairly positive statement, is, of course, not entirely satisfactory, and the process is not as simple as indicated. There seem to be no definite objections to this theory, however, while those which confront that of magmatic segregation either through the mass or at the cooler borders, appear to be insuperable. It might also be suggested that the highly aluminous Hudson River slates, which probably once covered the district, furnished the alumina, but no trace of them has been found in the field. There are inclusions of schist in the diorite area which are generally associated with a fine black pyroxenite, but around which no emery has been found to the writer's knowledge; although the farmers, judging from its toughness and color, believe that it is "full of emery." If it does not contain emery in any place—except possibly the very narrow zone almost on the contact, which we would expect by analogy from the effects at Crugers—it merely indicates that these inclusions were particularly quartzose and compact and retained their identity to an exceptional degree. As implied above, it is not the large, well defined inclusions from which we would expect emery to be derived, but rather the smaller fragments torn from these inclusions and probably entirely absorbed.

From this fact, it is evident that little can be predicted concerning the probable extension of the emery. While pyroxenite, being low in Al_2O_3 and high in MgO, may readily attack the schist, the usual association of the ore with this rock is not an essential limitation; and its relations to the borders of the area are vague and irregular. Possibly, a study of the mica schist at the borders nearest the mines might throw light on the particular variety of schist most susceptible of absorption, but this question has not been investigated by the writer.

The technology of corundum is discussed by J. H. Pratt.[83] From the composition of the Cortlandt emery as described above, it is evident that it is low grade ore. The presence of spinel, sillimanite, garnet, feldspar, quartz, etc., greatly lowers its cutting efficiency and materially affects its toughness. At the same time, the presence of spinel, which is 8 in hardness, would not interfere with the manufacture of a vitrified emery wheel; and for many purposes where extreme hardness is not required, the spinel emery furnishes a convenient transition between garnet and true emery. The unsuccessful attempt to smelt the more ferriferous varieties for iron has been noted above. Even earlier than this, it had been suggested[84] that the ore might be used as a refractory lining for the puddling furnace, open hearth and Bessemer converter, as well as an aluminous flux in the blast furnace in admixture with a siliceous stock, but apparently these sugestions have not proved practicable.

Summary

The Cortlandt Series is an igneous complex situated just southeast of Peekskill, N. Y., and is about 28 square miles in extent. Its correlation cannot be definitely settled, although it is probably late Paleozoic. The rocks have been described by J. D. Dana and G. H. Williams, the former attacking them from the standpoint of genesis, and the latter treating them rather as an aggregation of petrographic types. In the present paper, they are treated more from a geological standpoint, the differentiations made in the various broad types being directly proportionate to their areal importance. Reference to the appended map will impart the distribution and extent of the varieties determined, and on page 58 is given a diagram which indicates the most salient relations between the several types. The various differentiations of the norite magma are most centrally located; they are flanked on both sides by pyroxenites which extend to the west, and an unknown distance under the river, possibly as far as Stony Point, where they again outcrop. Between the norites and the western area of the pyroxenites lies a diorite area. The granites are more isolated, though unquestionably part of the series. The most basic members at least grade into one another in many cases, while at times, sharp contacts have been found. The analyses of the more important types indicate an unmistakable serial relationship, although complicated by the entrance of the pyroxenites. It is probable that the latter were intruded first, followed closely by the norites, so that

[83] Bull. 269, U. S. G. S., p. 159. 1906.
[84] J. P. Kimball, Amer. Chemist. IV, 321. 1874. This paper contains four analyses of the emery.

sometimes these varieties are found banded together in flow-like masses. The diorites must have come next, since the granites were evidently the last to form.

Dikes are abundant throughout the series and vary in composition from pegmatite to peridotite.

Many inclusions of schist, and some of limestone and gneiss, are found in the district. These are most prominent in the large diorite area and in the district near Salt Hill. At times, they have been absorbed by the molten magma, giving rise to very abnormal rocks. Contact metamorphism is also apparent around them, and on the borders of the series in places, developing in the schist an abundance of biotite, quartz, magnetite and many aluminous minerals; and in the limestone wernerite, diopside and other lime compounds.

Dynamic metamorphism is indicated by all of these rocks to a slight though constant degree; but this metamorphism sometimes assumes very marked proportions around the foreign inclusions in the district and in places from which the emery has been mined.

The economic geology is confined chiefly to granite quarrying and emery mining. The emery has been generally considered as an example of magmatic segregation, but more detailed work would seem to indicate that it is due to the absorption of sedimentary xenoliths. This would give rise to a magma supersaturated with respect to iron and alumina, from which emery would separate out according to the laws formulated by Morozewicz. This view of the origin of the emery is supported by its frequent, somewhat remote association with visible inclusions of schist; by its association with exactly the same suite of minerals as those developed on the borders of the district and in certain inclusions whose relations are unmistakable, and by its frequent occurrence banded with quartz, sometimes contorted and resembling exactly a black quartz schist.

PLATE III

PYROXENITE AND DIORITE

Fig. 1. Rounded form of olivine pyroxenite outcrop at Chase Corners, caused by the weathering of the olivine. This rock is never found in *roches moutonnées*, as are the other rocks of the series

Fig. 2. Stringers of Quartz Schist in Diorite, Buchanan

FIG. 1

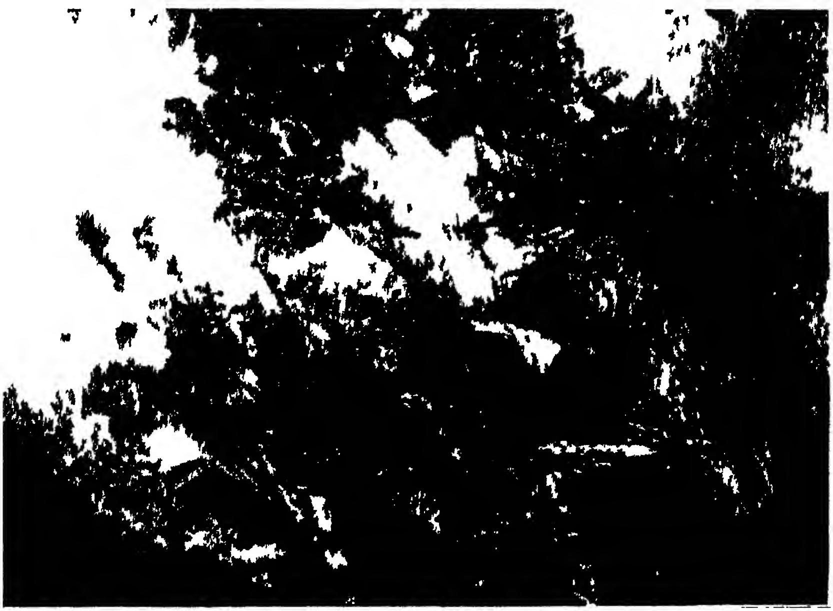


FIG. 2

PLATE IV

GNEISSOID STRUCTURE

Fig. 1. Original Gneissoid Structure, on road near Pleasantside

Fig. 2. Original Gneissoid Structure, one mile south of Spitzenberg Hill

Fig 1

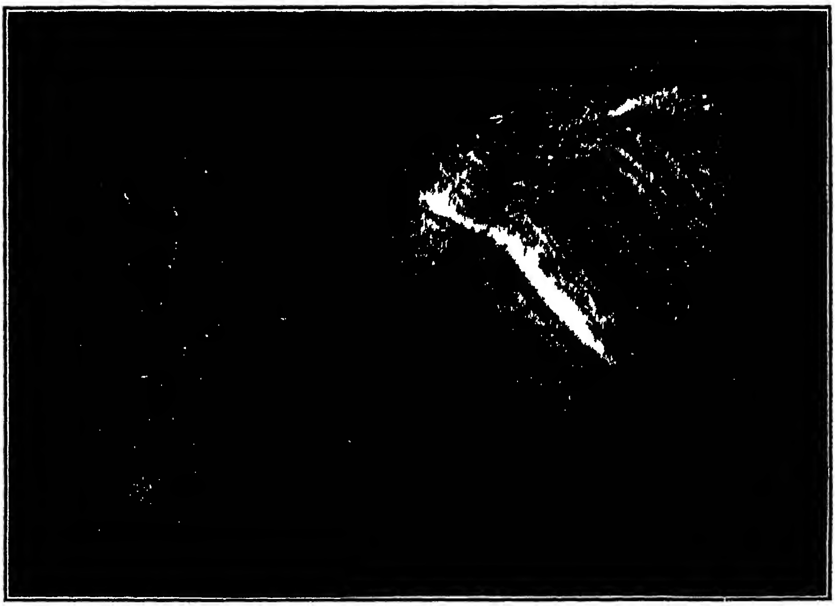


Fig 2

PLATE V

MCCOY MINE AND SCHIST

Fig. 1. The latest cutting in the McCoy Mine, showing the emery banded with sillimanite schist

Fig 2. Quartz Emery Schist, Salt Hill, showing the streaked appearance of this low grade ore

FIG. 1

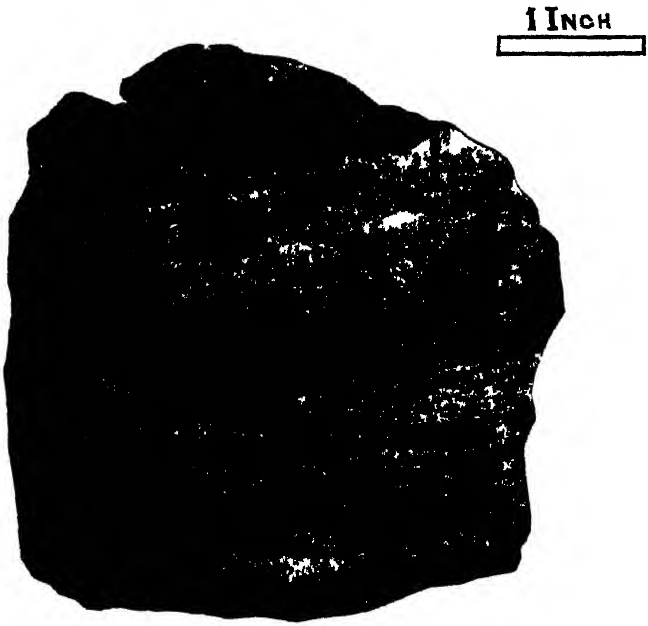
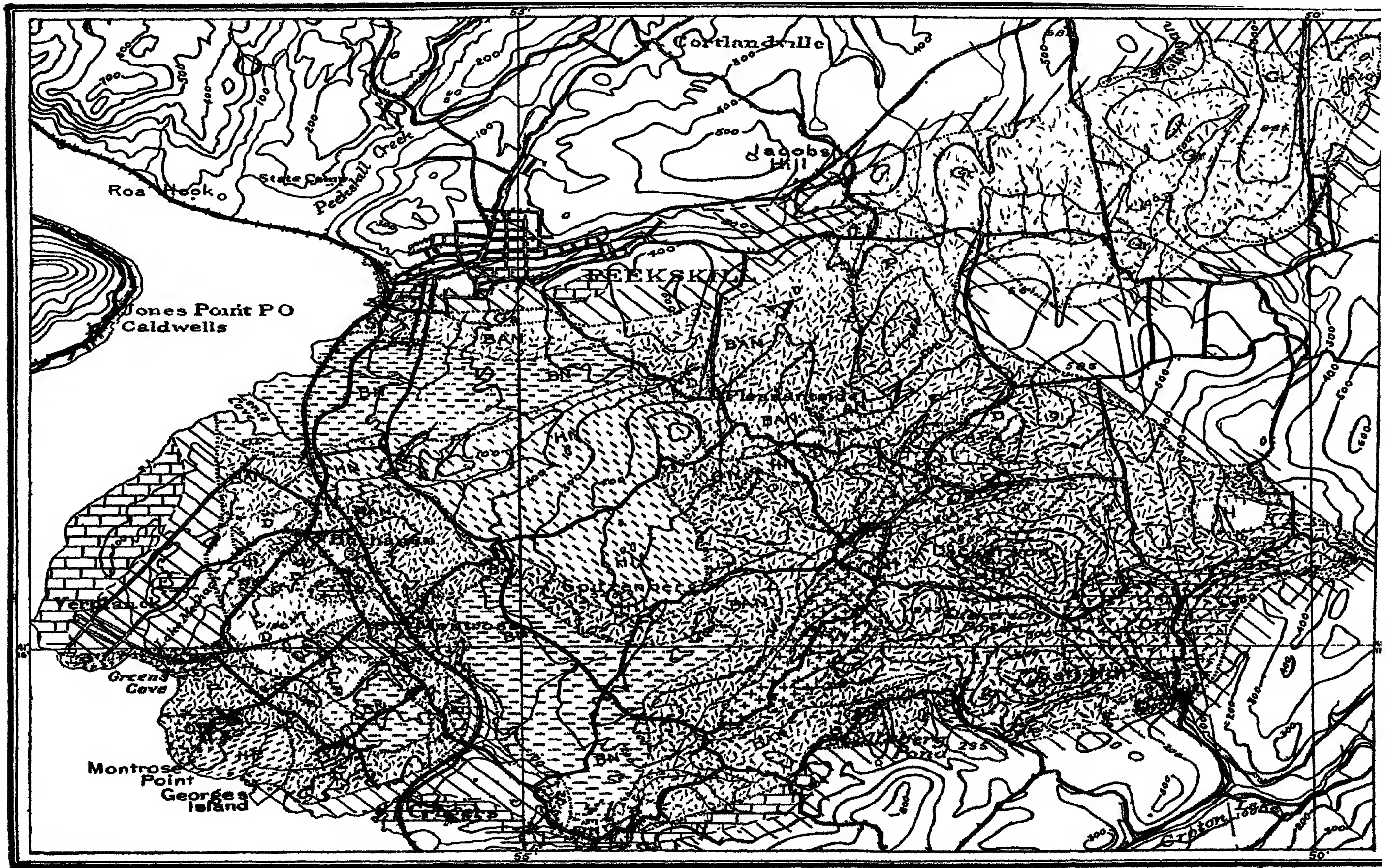


FIG. 2

PLATE VI

GEOLOGICAL MAP OF THE CORTLANDT SERIES



MAP OF THE CORTLANDT SERIES

Scale 0 ½ 1 2 Miles

Geology by G S Rogers, 191

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THE INFLUENCE OF HEREDITY AND OF ENVIRONMENT IN DETERMINING THE COAT COLORS IN MICE

BY T. H. MORGAN

CONTENTS

Introduction

During three years I have carried out some experiments in heredity with mice. My intention was to familiarize myself at first hand with the process of Mendelian inheritance, and for this purpose few groups of animals offer as many advantages as do the races of domesticated mice, not only because of the ease and rapidity with which they breed in confinement, but also because the relation of the colors has been more fully exploited here than in any other group. The varieties of color also offer an extended field for study. In the course of the work, some crucial experiments bearing on the theory of inheritance of coat color in mice were made, and these are given in the following pages. The discovery of a wild sport of the house mouse led to a study of its inheritance when crossed with domesticated varieties, and the more interesting results of these crosses are here given. Incidentally, I describe some experiments bearing on the theory of the inheritance of acquired characters as tested by artificial waltzers; a few cases of asymmetrical eye color are also described, and their meaning considered. The occurrence of a second wild sport is briefly mentioned. I have ventured to offer some suggestions concerning the factors involved in heredity of coat color in mice. In 1908 I brought forward a tentative hypothesis to account for the segregation of characters in Mendelian inheritance, and I pointed out at the time how this hypothesis might be tested. This test I have now completed, and the evidence that shows that it must be abandoned is here offered for the first time.

Crosses between a Wild Sport of Mus musculus and Domesticated Varieties

Description of the Wild Sport

Although many "sports" of wild species have been recorded, there are few cases describing their inheritance when bred either to the typical wild forms from which they arise or to domesticated races of the same species, when such exist. In the summer of 1907, I caught in a house at Woods Hole, Mass., a house mouse, *Mus musculus,* that had a pure white belly, chestnut sides and dark gray back. The mouse had come in from outside, since the house was new and had been closed all winter. Later, I caught two more such mice and, in the same closet, another typical house mouse. In the neighborhood, I have caught a few other white-bellied mice. They must be, therefore, not uncommon in the locality. In 1908, I had sent to

me from Iowa some mice caught in the fields, which were supposed to be *Peromyscus* because of the white belly. These were the same sports that I had obtained in Woods Hole. I have also found in the collection of house mice at the American Museum of Natural History in New York a few skins with the characteristic white belly. The sport must be, therefore, wide-spread. Since it appears to be found less often in the cities than in the country, it may possibly be a variety that occurs most often in the fields, or the conditions there may be more favorable for the appearance of the sport; and since, as will be shown below, it is a dominant type, it may in time spread and supplant the ordinary gray-bellied house mouse. Cuénot has recorded the appearance of this or of a similar sport in his domesticated races, but whether it arose there as a sport or was already present in some of the stock he used (in the yellow, for example) cannot be determined from his data. The sport resembles in all respects the house mouse except in color. The hair under the chin, neck and belly is pure white, the white extending to the flanks. Each hair has a dark base, *i. e.*, it is "ticked" and differs in this respect from the white spots seen in varieties of domesticated mice. This difference shows that the new sport has not arisen from escaped spotted mice. A narrow yellow band extends along the flanks between the fore and hind legs. The yellow band is strongly marked off from the white below, but less so from the gray of the sides above. The rest of the body is gray, but in most of my specimens, the gray is somewhat darker than that of the ordinary gray house mouse. Under the microscope, the hairs of the yellow flank are seen to have a yellow tip and a black base. The gray back also contains some hairs with a yellow tip and a black base, also hairs entirely black, while other hairs have a brown tip and a yellow mid-band. The white hairs of the belly have a white tip and a black base, while the ventral gray hairs of the gray-bellied mice have black extending nearly to the tip. The tip is yellow or nearly colorless. Even here, however, one meets with hairs that are yellow all the way to the base.

There are no intergrades between the white-bellied and the gray-bellied mice. There has never been any doubt concerning the nature of the several hundreds of mice descended from the wild sport that I have obtained. On the other hand, it should be stated that there is a wide range of fluctuation of the color of the ventral surface in the house mouse. Individuals are not uncommon that show a distinctly paler belly, but these belong to the common type, and since these lighter forms do not intergrade with the white-bellied sports or produce them, they rank with the common type with gray belly.

Cages containing the original wild sports and their offspring have been

maintained for three years. They have produced but few young, behaving in this respect like the ordinary house mouse when confined in a small cage. The males have, however, crossed freely with domesticated races and this happens also in the case of the house mouse. In most cases, my sports were bred to gray and produced white-bellied and gray-bellied young. In a few cases, the white-bellied forms when bred to each other produced white-bellied and gray-bellied offspring. On the other hand, two gray-bellied mice of this strain produce only gray-bellied young. These facts show that the white belly is dominant to the gray belly.

CROSSES BETWEEN THE SPORT AND DOMESTICATED RACES WITH UNIFORM COAT

The sports have been crossed with all of the ordinary varieties of domesticated mouse. The results in the first generation are shown in the following table, in a generalized statement.

Gray white-bellied by yellow = yellow, and gray with white belly.
" " " " gray with gray belly = gray with white belly.
" " " " black = gray with white belly.
" " " " chocolate = gray with white belly.
" " " " white = gray with white belly.

Like the wild gray mouse, the sport is dominant to all other colors except yellow. The sport, moreover, transmits its entire coat pattern when it dominates, and even when it becomes recessive in the yellow cross, the coat pattern reappears in the next generation.

We may now proceed to examine in detail the crosses summarized in the above table.

Crosses between the Sport and Yellow Mice

Six litters were obtained from male grays with white belly and yellow females, consisting of fourteen yellows and eleven grays. Of the grays six were recorded with white bellies, one with a gray belly, four not recorded for ventral color. Assuming that half of the yellow gametes bear yellow and half any other color, or colors, the results accord with theory. This cross was of particular interest because by it I wished to test whether yellow is allelomorphic to the other colors—gray, black and chocolate. If the yellow-bearing gametes bear only yellow, then all the F_1 yellows from a cross with gray should produce, when inbred, only yellows and grays as three to one (or two to one). If, on the other hand, yellow stands alone and is allelomorphic to its absence, then the offspring of the F_1 yellows

might contain other colors than yellow and gray. Owing to the sterility of the yellows, I have had poor success with this cross. Three litters only of the F_1 yellow by yellow were obtained. They gave ten yellows and two grays with white belly. In another case yellows were paired with grays with gray belly (from Iowa). Two of the yellows that resulted from the cross produced five yellows, five grays with gray belly and two cinnamon agoutis. In all therefore the F_1 yellows have given fifteen yellows and nine grays.

These results, while not so extensive as I should wish, indicate that the yellow-bearing germ-cell is pure for yellow in the sense that yellow is allelomorphic to gray. In other words, yellow has for its allelomorph in the hybrid with gray the combination of yellow-black-[1]chocolate that stands for gray. Whether chocolate and black are separate factors, or whether black is a development through chocolate, and if so whether an independent factor (not contained in the complex) brings about this change need not be discussed now, but will be examined later. Whichever of these views seems more satisfactory, the results of this experiment, as far as they go, show that the yellow-bearing germ-cell is pure for that color factor. The numbers are not large enough perhaps to put the matter beyond question. As far as they go, however, they indicate that the yellow gametes of the yellow mice carry only yellow, and that gray (and perhaps chocolate too) is allelomorphic to yellow. I lack the evidence to show the nature of the yellow pigment in mice, whether it is a lipochrome, as commonly assumed, or belongs to the melanin series. I must rest my case on the experimental evidence that seems to show that yellow is the allelomorph of gray (*i. e.*, of the colors that go to make up the gray). Since yellows may carry other colors latent, gray as well as chocolate or black, but only gray (black-yellow-chocolate) when gray has been introduced as such, either the ticking factor is a separate factor, or else some special combination (union) of black, chocolate and yellow exists which when present will give the ticked or barred condition to the hair. It may seem more probable that the barring factor is a separate factor that behaves independently of the other factors and when present produces its effect, except when dominated by the yellow factor. That this factor may act with chocolate and black alone without yellow is indicated below in the black-chocolate mice out of gray parents.

The F_1 white-bellied mice were crossed extensively with mice of other colors, and they produced white-bellied grays and other colors according to expectation. Gray bellies also appeared among the progeny when yellows were used, which is explained on the ground that the yellow mice

[1] The presence of black in this combination will be considered later.

carried the combination for gray belly. That yellow mice may have introduced into their composition the factor for white belly also is shown by the F_1 yellow crosses; also by an experiment in which one of these F_1 yellows bred to black produced some gray mice with white bellies.

I hoped to find out whether yellow mice bearing this factor for white belly have themselves in consequence a white belly, but owing to the great variability of yellows in this regard, I can make no positive statements. Most of my yellow mice have a lighter belly. I have seen some with a pure white belly superficially like those of the sport, but I have not tested them. In some of them, the hair was yellow proximally and white at the tips, suggesting possibly the presence of the ticking factor. I have also had yellows whose ventral surface was as yellow as the rest of the pelage.

Two of the F_1 gray, gray belly, were crossed with ordinary yellows and gave some gray, gray belly, descendants; none with white bellies.

Crosses between the Sport and Gray Mice

As stated, the wild sports that I obtained seemed to be heterozygous, since they produced both white-bellied and gray-bellied offspring. Sports V and VI, for instance, gave three gray, white-bellied, and one gray, gray-bellied young. Sport V crossed to a wild gray gave two gray, white-bellied and two gray, gray-bellied young. Sport I crossed to a pure race of extracted gray dominants gave four gray, white-bellied and one gray, gray-bellied young. One of the F_1 grays with gray belly, crossed to an extracted dominant gray, gave six grays with gray belly.

I have produced races of gray with white belly that breed true to this condition.

Crosses between the Sport and Black Mice

Sport III bred to a pure black female gave one gray with gray belly and two grays with white belly. Sport I (or F_1 ?) to black gave two grays, gray belly and one gray, white belly. Sport III, bred to spotted black gave four grays with white belly and one gray with gray belly. These results show again that the wild sports were heterozygous. When an F_1 gray with gray belly was bred to black there were produced three grays with gray belly and one black.

Crosses between the Sport and Chocolate Mice

Sport I crossed with a chocolate female gave five grays with white bellies. Sport V bred to chocolate gave three grays with white belly and two grays with gray belly.

Crosses between the Sport and Albinos

Sport I bred to a white female gave three grays with white belly and five grays with gray belly in one litter; and in a second litter, one gray with white belly and one gray with gray belly. Sport III bred to a white female gave four grays with white belly and one gray with gray belly.

In all, therefore, there were eight grays with white belly, and seven grays with gray belly, which is approximate equality and confirms the view that the sports used were heterozygous. None of the whites used appear to have contained yellow.

Crosses between F_1, Hybrid Sports and Yellows

One of the hybrid white-bellied mice (F_1) crossed to yellow gave four yellows, two grays with white belly, three grays with gray belly, one black and two whites. One of the hybrid grays with gray belly crossed with yellow gave two grays with gray belly, one golden agouti and two yellows.

Crosses between F_1, Hybrid Sports

Two hybrid grays with white belly, bred together, gave three grays with white belly. They may appear to have been pure, but the number of young is too small to make this certain. One hybrid gray with gray belly, bred to gray with white belly, gave three grays with gray belly and one golden agouti with gray belly.

NEW TYPE OF GRAY WITH A YELLOW BELLY

As ordinary gray mice grow older, the hair on the ventral surface often becomes yellowish. In some of the many offspring descended from crosses between the wild sports and domesticated mice, individuals have appeared again and again with the whole ventral surface distinctly yellowish in color. Some of those with deeper color have been paired and a race produced most members of which have a deep yellow belly replacing the white belly in the sport. This color is not due to age, for while it is true that it often becomes yellower as the mice grow older, I have found young mice, three weeks old, with a distinct yellow belly.

Under the microscope, the yellow hairs of the belly are seen to have a yellow outer end and a black inner part. The hair may be said to be ticked with yellow and black.

The introduction of yellow into the white belly suggests the possibility that the yellow is the result of crosses with ordinary yellows, but I can

find no records in my notes that show this to be the case. The color has appeared sporadically and does not appear to come through the yellows of the yellow crosses that have yielded relatively few mice compared with other combinations. Moreover, if the result had been due to yellow, we would expect it to appear only in the mice directly derived from yellow crosses, but this is not apparent.

Crossing Extracted Gray and Black to Test the Hypothesis of Alternate Dominance and Recession

In order to account for the two kinds of germ cells produced for each pair of characters by Mendelian hybrids, I suggested in 1905 that if instead of treating the question of segregation as the result of the separation of material factors, we treat the process as due to alternate dominance and recession of the paired characters in the gametes, we arrive at the same end results, viz., the formation of three classes of individuals in the second generation. This was an attempt to give a dynamic conception of the process of segregation instead of the conventional idea of separation of material particles as the basis of Mendelian inheritance. I advanced this view primarily to escape Cuénot's hypothesis for the inheritance of yellow which called in the aid of selective fertilization. Cuénot assumed that a yellow-bearing sperm never fertilized an egg bearing this same factor for yellow, hence all yellow mice arise through the union of two germ-cells only one of which carries the factor for yellow. Selective fertilization seemed to me highly improbable in itself, and if true in general for other characters it would lead to all sorts of irregularities in Mendelian inheritance. It now appears that the particular ratio of three to one, given by Cuénot[2] as the probable ratio for yellow in the second generation, is in reality a ratio of two to one, as Castle and Little have recently pointed out, so that the grounds for the original assumption by Cuénot fall to the ground. I pointed out at the same time certain logical consequences that followed, if my argument for alternate dominance and recession were valid, and I set to work to put the hypothesis to the test of fact.

The example that I used in my paper to illustrate the hypothesis of alternate dominance and recession, namely, the inheritance of albinism versus pigmented coat, was unfortunate, since it is generally conceded now that albinism is not due to the absence of the color determiner (gray or black, etc.), but to the absence of another factor, the color producer. It

[2] Cuénot discussed also the possibility of the two to one ratio.

is incontestible that this latter conception of albinism is better in accord with the facts.

The hypothetical interpretation that I offered involved primarily the idea, as stated above, that segregation may be a dynamic function of division in the germ-cells in exactly the same sense that specification of the cells to produce the organs and tissues of the embryo takes place during embryonic development. In this process, the results of experimental embryology had seemed to show that specification (segregation during cleavage) is not due to a separation of particles of chromatin, but to the dynamic action of the cells on each other at the time of or just before the division stages. Such a conception of embryonic segregation is still held by most embryologists, and I am still of the opinion, that if this is true for the ontogeny, it is true for the segregation that takes place in the formation of the gametes. My hypothesis was complicated, however, by the further supposition that such a dynamic segregation in the gametes carries with it the idea of impurity of the gametes in the sense that it allows as a possibility that the extracted recessive may under certain conditions give rise to the dominant, and conversely that the dominant may at times produce the recessive type. One especial condition that I assumed to call forth the latent character in the recessive form was the process of hybridization. I pointed out how this interpretation could be tested and its truth or falsity established. If, for example, we cross an extracted dominant gray mouse (one that has had white in its ancestry) with a pure black mouse, the offspring in the first generation should all be gray; but if the presence of the black can call forth the latent white condition, some white mice should appear in subsequent generations of the gray hybrids.

The gray mouse used in my experiment was from a race of extracted dominants that produced only grays. The black mouse was given to me by B. B. Horton, and was from black stock that he had formed which gave only blacks. In the first generation grays only were produced. These inbred produced grays and blacks. The third and fourth generation of some of these mice were bred in several combinations and continued to produce only grays and blacks (Plate VIII, figs. 2, 3). It is evident that the hypothesis failed when tested and must therefore be abandoned.

Crosses between the Spotted and the Uniform Coat

The experiment was undertaken originally to examine the inheritance of spotted coat versus uniform coat. Owing to the difficulties in obtaining crosses in large numbers between waltzers and other races, this side

of the experiment has not yielded as extensive results as I had hoped for. In conformity with the statement of Cuénot, I found that when the spotted mice (waltzers) were crossed with races having a uniform coat all the mice in the first generation were uniform. In the second generation (F_2) both uniform and spotted coats appeared, the former in excess. Cuénot gave the usual Mendelian ratio 3 : 1 for this generation. I have found difficulty in deciding how to classify the spotted mice, for they range from those spotted like the original waltzers to those with only a few white hairs on the belly or even at the tip of the tail. It is apparent that, if the original coat characteristic of the spotted waltzers be taken as the recessive character, this particular coat or its equivalent in spottedness reappears in much less than one fourth of the second generation. I chose a race of waltzers obtained from Prof. R. M. Yerkes that had a known history. This race has not, it is true, a fixed spotted pattern, but within certain limits the amount of white to black is fairly constant. In marked contrast to this condition is the series of forms in the F_2 generation that range, as stated, from the uniform coat to the original spotted condition. It is perfectly evident that, as a result of crossing, the uniform coat has encroached on the spotted coat, so that the latter now has a far greater range in one direction than before. In a word, the spotted coat in the F_2 generation more often approaches the uniform coat than does the original race. It is clear therefore to my mind that the relation of spotted coat to uniform is far more complicated than the Mendelian ratio requires and that hybridizing introduces a new factor or modifies the old one. The spotted coat may in fact be said to have been contaminated by the cross, so that in most cases segregation, if the process can be said in fact to be one of segregation, is less complete than before.

The problem of the spotted coat is one that has not been clearly brought into line with other interpretations applied to Mendelian inheritance in mice. For instance, if, as Cuénot has suggested, the albino condition is due to the loss of a color producer (C), then this factor must be absent from the white regions of the spotted skin, yet the factor must be present in other parts of the body of the same spotted animal that produces color. Hence both the color producer and the color determiner must have been present in the fertilized egg. It does not seem to me to render the difficulty any less by introducing a spotting factor, unless its mode of action can be made to conform to the physiological action involved to explain the presence or the absence of color in other races, for there can be little doubt that the physiological process that produces yellow, gray, black or chocolate spots is the same as that producing the same colors in the uniform coat. On the other hand, it is evident that spotted mice are

different from mice with uniform coat on the one hand and from albinos on the other, and that they carry something that causes spotting, however variable, to reappear in the second generation. It is well known that crossing spotted animals to albinos does not increase the amount of white in the spotted coat. On the contrary, if the albino is derived from a colored race with a uniform coat, the first generation may be uniform and the second variable to the same extent as though a uniform coat had been used. It is clear that the albino condition is not related as such to the spotted condition. The paradox seems to me to find its solution in the assumption that the spotted coat is not segregated from the uniform coat as a "unit character" in the germ cell, but that it represents a process which occurs in the early cleavage of the egg when the A factor is separated in certain cells from the C factor. In other words, some of the cells lose the C factor and the regions derived from these cells are therefore white. The well-known variability of the coat pattern that has been so difficult to fix as such can be explained in this way, owing to the irregularities in the process that leads to the loss of C, or to subsequent shifting of the cells. Three corollaries follow from such an assumption: First, that there is no "spotting factor" as such that segregates in the germ cells of the hybrid animal. All the germ cells contain the factor for color producing and color determining—the loss comes later in the ontogeny. It is this tendency to separate late that is inherited, and I have no objection to calling such a tendency a spotting factor, provided that we do not confuse its method of action with what occurs in ordinary segregation.

A second corollary is that the tendency to dissociate in the cleavage stages may also be supposed to occur in the hybrid of the first generation, but, since the other factor[8] that stands for uniform coat (*i. e.*, no dissociation) is also present, the separation may not normally be evident, although in rats, as I have pointed out, even in the first generation the occurrence of dissociation is manifest in certain parts of the body.

A third corollary also follows. Since crossing spotted and uniform coats leads to a production in the F_2 generation of a long series of intermediate forms, we must infer that the tendency to dissociate has been modified by crossing with the uniform coat. It has become modified in the sense that it is often shifted to a later stage in the cleavage, hence the great variability observed in the second or F_2 generation. Cuénot and, later, Castle have shown that the spotted condition may be gradually shifted in the direction of selection. Cuénot showed by continued selection of lighter colored mice (*i. e.*, spotted mice with more white) that the char-

[8] The doubleness of each factor makes such an assumption possible.

acter of the coat shifted in later generations in the direction of selection; and Castle has shown for rats similar shifting by selecting the darker coat pattern. If my interpretation is correct selection here affects the stage at which the "segregation" occurs in development. The cause of this shifting must still obviously go back to some change in the germ cells, but the change so brought about does not, from this point of view, cause a change in the character of the coat carried by the germ cells, but a change in the factor that determines when the segregation takes place in the cleavage of the egg.

The uniform coat appears to bear the same relation to the spotted coat that the uniformly colored hairs (yellow, black, chocolate or white) bear to the gray or ticked hairs. From this point of view the "ticking factor" has the same theoretical value as the "spotted factor." It is, of course, a fiction to assume that all the hairs of a gray mouse are alike and consist of the three bands—black, yellow, chocolate—in the same relation. A casual examination of the hair under the microscope will suffice to show the wide range of variability that exists and the numerous departures from this rule. The variability is almost as great as that shown by the spotted coat. Nevertheless, in a general way, most hairs of the body may be said to conform to this scheme.

I have met with this same problem in certain mutations in *Drosophila*. In one case, a heterozygous fly had one white eye and one red one. Here the separation must have occurred after the egg had been fertilized. The tendency was not inherited. The point will be discussed below. On two occasions, I have had a heterozygous fly that had one normal wing and one small "proportionate" wing. These flies when bred to males of the race with proportionate wings (the recessive) have produced both long- and short-winged individuals, showing the heterozygous nature of the original asymmetrical fly. I then crossed again the long and short flies to bring about the same heterozygous combination, in the hope that the "asymmetrical factor" would come to light again, but of several hundred offspring not one was asymmetrical.

Influence of the Spotted Coat on the White Belly of the Sport

The wild sport was crossed on several occasions with spotted mice. The hybrids were gray mice with white or gray bellies. The former when inbred produced some spotted mice with white bellies. An examination of these mice showed that whenever a white spot extended into the region of the white belly, the black at the base of the hair that is present, as stated, in the ordinary white belly is absent. In other words, the spot

affects the "white" belly-hair in exactly the same way as it affects the hair elsewhere—all color is lost.

As is known, the spotted condition affects all mice of whatsoever color, whether yellow, gray, black or chocolate, in the same way. If a yellow-spotted mouse is crossed to a mouse with uniform coat of gray, black or chocolate the spotting disappears in the first generation and the uniform coat is yellow in some of the offspring. If these yellows are inbred, the spotting recurs, not only in some of the yellow offspring but in the other colors as well. The spotted condition is not therefore associated with any peculiar color, but affects all equally and can be transferred from one to the other as stated above. If we interpreted the absence of color in the spotted white areas as due to a factor that suppresses color in these parts, it would follow that it affects yellow in the same sense in which it affects black and chocolate, and the ticked condition of the gray also. On such a view we might argue logically that yellow belongs to the same series as the other colors, since it is suppressed by the same factor. Furthermore, if, as is generally believed, the spotted condition is due to the *loss* of the color producer, so that the color determiner can no longer act to make the color, then we are equally led to the conclusion that the color producer for yellow is the same as that for the other colors—a conclusion of some general importance.

Returning to the change in the white hair of the belly of the sport, when a white spot crosses the white belly, it is evident that the effect is due to the loss of the color producer, so that the hair is white to its base. This view is, of course, in line with the interpretation of the white belly as a ticked region.

This leads to a consideration of the ticking or barring factor. Obviously it is the same sort of thing as the spotting factor, only it appears in each hair instead of in different regions of the body. If we push our hypothesis to its logical limits, we must conclude that when the cells that form the hair are laid down, during the earlier divisions of the cell (or cells) from which each hair arises, there occurs a series of losses in the different cells, so that the terminal cell and its descendants have lost the determiners for yellow and black, leaving chocolate, the next cell or cells lose the determiners for chocolate and black leaving yellow, and the last cell of the chain retains only the black determiner. Similarly in the white belly, the outer cells of the follicle have lost the color determiner either for yellow or black, or the color producer, while the basal cells retain the determiner for black as well as the producer. Since yellow may appear in the yellow-bellied race in the outer ends of the hair it appears simpler to suppose that it is the color determiner that is lost.

Crosses between the Black Spotted Waltzer and Mice with Chocolate Coat

In a litter of mice from a chocolate female and a male black and white waltzer, there were present young mice that are described in my notes as gray. At that time, I was perfectly familiar with the different coat colors of mice, yet I did not hesitate to describe the color as gray, although aware that gray could not, theoretically, arise in this way. As the mice

Fig. 1

Fig. 2

Crosses between Black-spotted Waltzer and Chocolate-colored Mice.

grew older, they became spotted with black (like the mice of Plate VII, figs. 3, 4), and later entirely black. I thought therefore that I had probably made a mistake in my determination of the color of the young mice, but such mice have later appeared not infrequently in the offspring of such crosses (see Text-figures 1 and 2), and a study of their hair has shown that there are some grounds at least for confusing their color with gray. The

gray-looking black-chocolate mice often show a stratification of these colors in many of the hairs. The outer end is chocolate and the base black. The yellow band of the gray mouse alone is missing. In other words, the ticking factor has reappeared and affects the distribution of the only two colors present, namely, black and chocolate. The mice may be said to be "grays without yellow." On the other hand, these mice often turn into black mice, often in spots, so that some of the curious patterns shown in Plate VII, figs. 2, 3, 4, appear temporarily at least. These patterns usually last several weeks or months and then generally change to a uniform coat or to a different arrangement of the color area. Conversely these same or other mice often change from a uniform color to a black-chocolate spotted animal. The condition of the animal—its "physiological state"—induced by change in the environment at the time of moulting, is probably the cause of these differences. It seems probable that the "ticking factor" is able to assert itself only when the conditions are of a particular kind.

When the hair of these mice is studied under the microscope, a very complicated series of relations becomes manifest. Many of the hairs are ticked as described, but to various degrees; others may be uniformly black, etc. Among the mice that have originated through crosses between strong and dilute races, I have often met with color changes in the coat, often local, sometimes general, that are related in some way to the presence of the two factors, that stand for dilute and strong color (Plate VII, fig. 1). Gray mice may at times also show areas of lighter and darker color, and these may come and go with each molt (Plate VIII, figs. 1, 2).

When examined under the microscope, the light hairs show a lessening of the pigment granules in different regions, a lessening that is a characteristic feature of the so-called dilute condition. Here again we can only refer these effects to the conditions, often transitory, that affect the heterozygous animals. This variability raises the question as to whether the ticking factor is in reality present in the "waltzer-chocolate" hybrids. May not the result be expressed in terms of strong and dilute? I am not disinclined to such an interpretation, provided that black and chocolate bear this relation to each other. This question will also be deferred for treatment to the final conclusions, but one further question may be briefly mentioned here. The supposed origin in China of the waltzing mice, the peculiar shape of the head, their size and the proportions of the body strongly suggest that they belong to a different race (or species?) from that from which our common domesticated mice have arisen. If this can be proven, it may be that they have not lost entirely the ticking factor, but that black is epistatic. By the introduction of chocolate, the possi-

bility of the ticking expressing itself may be realized, so that the "gray without yellow" may in reality be a ticked hair, as first suggested.

Although I have made no measurements or weighing, it appears that the hybrids between the waltzer and common mice are larger than the waltzer and possibly not as large as our common domesticated races. In the second generation, I have obtained both large individuals and small mice, as well as intermediates, the first as large as our common form, the latter as small as the waltzer. It appears that the size character also segregates, at least to some extent.

Yerkes has pointed out that the older waltzers are deaf. In order to study the inheritance of deafness, I tested many of my domesticated races of mice and found that in them also there is a large percentage of animals that seem to be entirely deaf. It becomes evident, therefore, that the problem would be complex, unless races were first produced like the waltzers that are uniformly deaf, but as I had no such races and did not succeed in crossing wild mice and waltzers, it does not appear worth while to give here the result of my observations on my hybrid mice. I hope to continue this experiment later.

Artificial Waltzers

The curious effect of acetyl-atoxyl on mice has been described by Ehrlich. It causes them to run about in circles in much the same way as do the true Japanese waltzing mice. This coincidence in behavior led me to test whether mice that have been made to waltz by artificial means would transmit their acquired character.

The injections were made for me by Dr. B. T. Terry, of the Rockefeller Institute for Medical Research, and I am greatly indebted to him for the time and skill expended in producing these waltzers. In some cases, one injection sufficed to bring on in a few days the circus movements; in others, two or three doses were necessary, and some mice failed entirely to become waltzers. In one case, the mouse was pregnant and the injection caused abortion of two of her young, but the rest of the litter developed to full term. None of these waltzed later.

I have made a number of pairings between the artificial waltzers and normal mice. None of the offspring waltzed, but since the waltzing of waltzing mice is recessive, this might be expected to occur even if the habit is inherited. Therefore I inbred these F_1 mice, but obtained only normal mice. In two or three cases, I have had young from a pair that were both waltzers. None of these or their progeny waltzed. I conclude, therefore, that so far as the evidence goes, the acquired character is not transmitted. Although the results were negative, nevertheless the evi-

dence seems peculiarly significant because of the occurrence of a race of domesticated mice that breeds true to this character. The test is even more significant, when we recall that the waltzing habit when induced artificially seems to be permanent. I have kept artificial waltzers for more than a year and at the end of that time they waltzed as well as at first. It seems probable, therefore, that the drug has caused a permanent change in the animal, and since it is known to produce degeneration of certain nerve fibres in man, it seems not unlikely that the effects in mice are of the same nature. Yet, despite the permanency of the effect, the acquired character is not transmitted through the germ cells.

Dr. Terry has also produced for me a number of waltzing rats by means of larger doses of atoxyl. Unfortunately, none of these have bred when both parents were waltzers.

Are Black and Chocolate Different Pigments or Stages in the Development of the Same Pigment?

There are two methods of treating the colors black and chocolate in mice. They are generally considered to be different unit characters and the product of different factors, but I have found some evidence that indicates that these two pigments may be intimately related, and I suggest that they may represent different developmental stages of the same process. From this standpoint, black is a further development of the same chemical process that produces chocolate, and since pure black and pure chocolate races exist, there must be some special condition or factor that leads to the further development of chocolate to make a black mouse. Let us represent this higher stage by the symbol M. A black mouse is, therefore, Ch Ch MM, and its gametes are Ch M and Ch M. A chocolate mouse is Ch Ch. When black is mated to chocolate, the hybrid is Ch Ch M, which gives in the next generation three blacks to one chocolate. Similarly when chocolate Ch Ch is crossed to gray (Y Ch) M, the first generation will be gray, and the second will contain gray (including cinnamon agouti), black and chocolate in the proportion 12 : 3 : 1.

The dilute colors, blue (or dilute black) and silver fawn (or dilute chocolate) require special consideration. Dilute black is not chocolate, as Cuénot supposed, but the dilute effect is due to the sparseness of the black granules. Similarly dilute chocolate owes its peculiarity to the fewness of the chocolate granules, rather than to their weakening. The experiments of Miss F. M. Durham show that the factor producing sparseness in black produces the same effect in chocolate. This factor, *S*, is not to be confused with the factor *M* that transforms chocolate to a higher stage—*i. e.*, into black. When dilute black is crossed with choco-

late, the offspring are black. This result is obvious on the explanation here offered; for the factor that produces the abundant development of the granules is supplied by the chocolate mouse, while the color of the granules is determined by the dilute black parent. Such an interpretation is, as far as I can see, completely in accord with the facts, and I venture to think that it offers some advantages over the schemata so far offered, in that the peculiar relation between black and chocolate in heterozygous black becomes more intelligible. In these mice, most of the pigment is carried on to its higher stages, viz., black, some remaining, however, at the lower stage; and the extent to which the process is carried out depends on the physiological condition of the mouse at the time when the hair is laid down.

Asymmetrical Eye Colors

In the winter of 1907, I procured from Dr. H. L. Wood, of Groton, Conn., a dilute colored mouse that had one pink eye and one black eye. The same condition reappeared again in one of my own mice, probably related to Dr. Wood's. It is known that angora cats often have one blue eye and one green one, and that coach dogs and other races, and man also, sometimes have eyes of different colors, but I do not know of any other records where one eye is black and the other pink (albino). The mouse belonged to a strain of colored mice with pink eyes that Dr. Wood had imported from England. Some of the mice were spotted with white, which may enter also into the problem. I bred this mouse to other black-eyed mice of the same stock, but obtained no asymmetrical offspring, either in the first or in subsequent progeny. The condition appears, therefore, not to be inherited in the ordinary sense, but to be rather what I have called an ontogenetic process of segregation which takes place for this combination only rarely. Nevertheless, the phenomenon rests on the same basis as that for the spotted condition in general, but in this instance it is not fixed and appears only sporadically. I have had one other mouse, as stated above, with one black eye and one pink eye from related stock, but in none of its progeny did the condition reappear. In another combination, I have found one mouse with one pink eye and one ruby eye. The mouse itself was chocolate.

Dilute Grays

In the course of the large number of crosses that I have made between different races of domestic mice, there have been produced some dilute forms of gray. I mention these facts here not only to put on record the

production of such forms, but also to show that, being aware of their occurrence, I have been less liable to confuse the unusual colors that I have described—such, for instance, as the black-chocolate that simulates gray.

The lighter races were made by crossing dilute chocolates with cinnamon agoutis and then extracting, or by crossing light black with cinnamon agoutis and extracting. In the former case, some of the F_2 mice were extremely pale, and the chocolate band appeared to be dilute. In the latter case, one might expect to obtain some mice in which both the black band and the chocolate band were dilute. In fact, I have had several kinds or at least colors of dilute mice with ticked hair, but I hesitate to class them under these two groups without further and more careful examination, because these dilute forms appear to be variable and the color of the coat may change with every moult. One of these changing coats is shown in Plate VIII, fig. 2, where the combination gives a remarkable contrast.

Crosses between Black and White Spotted Waltzers and Yellows

In order to test in another way whether the yellow gametes of yellow mice carry the factor for other colors than yellow, I crossed a yellow with a black and white waltzer of known pedigree that carried only black. Two yellow mice from this cross were inbred and produced a litter containing yellows, blacks and chocolates. I concluded that the yellow gametes may carry in addition to yellow the factor for chocolate. Cuénot objected to this conclusion, on the ground that my original yellow contained the diluting factor, which, according to his view, changes black to chocolate. Cuénot's objection will not hold for two reasons. First, because chocolate is not due to the diluting factor for black, since Miss Durham has shown that the dilute form of black is not chocolate, but dilute black or blue. Second, because if the diluting factor were present, the later generations of these mice should make evident its prsence, which was not the case. Nevertheless, I now believe that Cuénot's objection holds good in principle. If, as I have attempted to show, black is a higher development of chocolate, the black waltzer must have contained in duplex this factor that changes chocolate to black, and his spermatozoa must have contained this factor only in the simplex condition. The yellow mouse in question must not have contained this factor, hence the yellow offspring (F_1) contained it only in simplex form. It will be present or absent, therefore, in their gametes. Those containing it, and the factor also for chocolate, will give black; those without it will give

chocolates. The result can therefore be brought into line with those of the gray-yellow crosses, but only if we treat chocolate and black in the way here suggested.

A Mauve-colored Wild Sport

Through the kindness of L. C. Bragg, I obtained the skin of a mouse caught in Colorado far removed from any possible source of contamination with domesticated races. Several of these mice were caught in the same locality and were kept alive by Mr. Bragg for some time. All attempts to procure others have so far failed. The color of the sport is so peculiar that I believe it worth while to record it here, for we know very little concerning the origin of the domesticated races of colored mice or of sports of the house mouse. The general color of the mouse is yellowish brown or mauve. A microscopic examination of the hair of the back or sides shows the presence of black pigment granules in the proximal half of each hair, and yellow pigment in the outer part, except at the tip, which is colorless. In addition, some of the large hairs contain black pigment nearly to their tips. Comparison with the hair of the ordinary house mouse shows that the base of the hair of the mauve mouse is much less black than is the ordinary hair, and that the yellow brown pigment is identical with that in the yellow band of the gray mouse. The mauve mouse appears, therefore, to owe its color to the loss of chocolate, and perhaps to a lightening of the black color at the same time; but the latter effect may be due to the absence of chocolate in the black portion, where it appears to be mixed with black in the ordinary mouse.

The Influence of the Environment on the Color of Peromyscus leucopus ammodytes

The intergradations between many of the species of *Peromyscus* has made their identification and classification difficult. The occurrence of intergrades in regions of overlap may be explained either as the result of interbreeding of the more typical forms found elsewhere or as the effects of the environment. Both of these questions might be studied, I thought, by breeding the mice in confinement. In the winter of 1907, and during 1908-9, I kept several species of *Peromyscus* in the laboratory—species from the Eastern States, from Florida, Texas, California, Colorado, Indiana, Ohio and elsewhere. The results have been meager because in most cases the mice failed to breed, both when like was bred to like and when different species were kept together. In the summer of 1908 and again in 1909, I collected the local races of *Peromyscus* found on Mono-

moy Island and on Marthas Vineyard. Experience had taught better methods of keeping the mice, so that I have been able to rear these types in confinement and have obtained crosses between them. The results of these crosses may be described at another time; here I wish to record certain facts connected with a change of color in confinement. The change in color has been more marked in the Monomoy variety than in any other form. This species lives on the sand hills of the small island of Monomoy off the southern coast of Massachusetts. In its natural habitat this variety is in general much lighter than the mainland form. The white hairs of the belly are white to the base, while in the mainland type, *P. noveboracensis,* the inner end of each hair is dark. There is a good deal of variation in the degree of lightness of the upper surface of different individuals, which Bangs suggests is the result of mixing caused by occasional migrations, when the island has been for a time connected with the mainland. Some of the specimens that I have collected and have obtained alive from Monomoy are as dark above as the mainland form, while others are quite pale. Similarly, in the laboratory, great variation in color in these Monomoy mice exists, and the mice have shown themselves more susceptible to change than the other species and varieties kept under similar conditions. The most extreme change is shown in Plate IX, fig. 2. For comparison, one of the lighter individuals found in nature is also figured (Plate IX, fig. 1). The modified form has lost even the light gray color of the island type, except for a patch on each side of the body and another on the head, and has assumed a pale bluish-pink color that is well shown without exaggeration in the figures. When seen with other mice this mouse looks almost white. A microscopic examination of the light hairs shows that the outer two thirds of the hair from the middle of the back is entirely devoid of pigment, but near the base of the hair some black pigment is present. The color of the mouse is due, therefore, to the darker base showing through the clear outer ends of the hairs. The effect, as stated, is to give a faint bluish-pink color to the mouse, when seen from above or from the sides.

The stock in which this mouse appeared came from Monomoy in the summer of 1909. It was kept in a large cage in the attic of the laboratory throughout the winter and in an upper room in the laboratory for a part of the summer of 1910. The mouse was found in the condition figured at the end of the summer and has remained in the same condition for six months. The cage in which it was kept had producéd young mice in the spring which had not been removed, and, as I was absent during the summer, I can not state whether this particular individual was one of the original mice from Monomoy or one of their young that had be-

come full grown. Several other mice in the same cage showed a similar change, but none so great as this one. The others showed patches of lighter color and these may disappear again after several months or new patches may appear. Similar effects, though not so great, have also been seen in the mainland forms kept under the same conditions and also in some of the mice from Marthas Vineyard. Other species also kept in confinement have shown similar lightening of the coat color. Osgood[4] states for *Peromyscus leucopus noveboracensis* that the coat is being continually moulted or "changed," although it appears to be entirely renewed only once a year. The changes in color that come and go are undoubtedly connected with the partial moulting of the individual, and it seems reasonable to suppose that they are expressions of the physiological condition of the animal at the time of moult.

The important question as to which factor or factors in the environment is responsible for the changes in color here recorded can not, I regret, be given. Light seems to be excluded, since the animals are crepuscular, and the room in which they were kept was lighted by a window, so that in this regard the conditions were not very different from those in nature. Food or temperature or humidity might be supposed to be the factors that are probably involved. The food was varied, but contained less green food than the animals generally obtain. The temperature was much higher on the average than that to which the animals are normally exposed. The air of the attic was extremely dry, yet it is to be remembered that this lighter-colored race has arisen on an island where the moisture is extremely high, so that if there is any relation between the color and the environment, we should expect dryness to produce the reverse effect. Until control experiments can be carried out, it will be best not to assign the change to any one of these possible agents.

How far these changes may be carried in later generations remains also to be shown. It is, however, sufficiently obvious that, if changes as great as these may take place, the results of crossing different species in confinement must be carefully controlled by studies of the influences of the confinement itself.

General Conclusions

THE TICKED OR GRAY HAIR AS A "UNIT CHARACTER"

Under the microscope, the hair of the common gray mouse is found to contain three pigments, black at the base, yellow in the middle and brown (or chocolate) at the tip. This banded condition is obviously like that

[4] Revision of the mice of the American genus *Peromyscus*. North American Fauna, No. 28. 1909.

seen in many animals in which the tip of the hair or feather or scale is brightly colored and the base dark or black. Obviously the peculiar feature of such structures is the stratification of the color bands. The cells first formed in the follicle must produce one color, then another, and later a third. The possibility of producing all three must be present at the beginning, and a "morphogenetic factor" of some sort determines the activity that leads in turn to the formation of one after the other of these colors. It must be at once granted that we know no more of the nature of such a factor than we do of the differentiation that appears in the development of any of the characters of the embryo. To ascribe it to a "ticking factor" is no more than to describe the phenomenon in general terms, since we know nothing of the method of action of such a factor. The fact that the ticking factor may be carried by the yellow mice that also carry black or chocolate (or both) and yet not come to expression is one of the peculiar features of the yellow inheritance.

That the development of the ticked coat is a specific element in heredity can not be doubted, and, admitting the purely symbolic nature of its representation, I see no objection to calling it in the ordinary sense a unit character.[5] It is interesting to see how it has been treated in Mendelian literature.

Cuénot uses the letter G as a symbol for gray and treats it as allelomorphic to the other colors—yellow, black or chocolate. Its presence produces a gray mouse, which in his formulas is never treated on the presence and absence theory, but always as allelomorphic to yellow or black or chocolate. Yet for its expression the presence of all these three pigments must occur. It is in fact a bundle of these three pigments with the added condition of their stratification. There is obviously an obscurity here, unless the group of colors that stand for ticking is inherited as a unit in allelomorphic relation to either of the three colors considered by themselves.

Bateson's symbolism for gray in mice is G B Ch C, to which yellow must, I believe, be added, giving Y G B Ch C. Miss Durham omits the C unit and makes Ch its equivalent, or at least suggests such a possibility. In these formulæ, G is called the gray determiner which is equivalent to ticking. Bateson adds, "The important question, what the effect of the gray determiner, for example, actually is, remains undecided." Bateson represents the black mouse as C g B Ch and chocolate as C g b Ch. In these formulæ small g and b stand for the absence of the gray and the black determiners.

[5] This statement leaves open the nature of the factor that produces such a "unit character."

Two questions arise in this connection. The determiner for chocolate is not represented in the presence or absence scheme, since it has never been found absent—*i. e.*, no white mice have been recorded from which all determiners are absent. Such a mouse would be represented by C g b ch. Why, it may be asked, is chocolate excluded from the presence or absence relation? If the chocolate determiner is equivalent to the color producer C, then it too might be absent from some albinos (or from all); yet it can be shown that albinos that do not carry other factors carry chocolate, which is contradictory to the assumption. It may be claimed, however, that the chocolate factor has never dropped out in the past; hence its presence in all mice and hence the impossibility of treating it on the presence or absence scheme. Such an interpretation is logical at least.

In treating the heredity of color in guinea-pigs and rabbits, Castle considers gray as the result of the presence of a ticking factor. In these rodents the gray or agouti may be produced by crossing a black and a red (yellow) individual. Only certain blacks and reds give the result. Castle concludes that some blacks and some reds contain the ticking factor. So long as only one color is present, either black or red, the action of the ticking factor is rendered impossible, since it takes at least two factors to produce the stratified layers. Hence a black animal with the ticking factor is still black, and so is a red only red, but when combined, the presence of red and black and the ticking factor gives again the agouti; but it is not clear why a black animal with the ticking factor should not have the outer ends of the hair (where the red lies in the ticked hair) colorless and the base black. This condition actually exists in the white belly of my wild sports. On the other hand, yellow mice do carry the ticking factor, and yet the hair is uniformly or at least continuously colored yellow, although here too some of my yellow mice with white bellies have a white tip and a yellow base to each hair. If the red guinea-pig is equivalent to the yellow mouse, it may be that the ticking factor can be carried by this type alone and not by the blacks. This view would make the two groups conform, but Castle's evidence seems to show that a yellow that gives agouti with one black may not do so with another. If his cases are sufficiently numerous to show that this is not an accidental result owing to his reds being heterozygous for G, then the suggestion here offered is unavailing.

In mice, I have found clear evidence that black and chocolate may be stratified to produce a resemblance to gray. Such cases clearly show that in these animals the factor for ticking may be present and effective in the absence of yellow. To prove that this is due to a true ticking com-

parable to that of the wild gray mouse, such mice should be crossed to a yellow strain that contains no ticking factor and gives rise to some gray mice. This test I have been unable as yet to apply.

Castle has also suggested that melanistic forms of gray animals arise through the loss of the ticking factor. In consequence, the colors are not laid down seriatim and the darkest color becoming epistatic gives the black color to the hair. The implication is that the yellow and the chocolate are still present but obscured by black. By a further loss of black the chocolate stains the hair and a chocolate animal results. Two difficulties with reference to this view suggest themselves. It is assumed that the loss of the ticking factor will lead to the uniform spread of the other colors, but this is not self-evident or proven. I have tested a few black mice and found no yellow present.

Secondly, yellow itself may completely color the hair in a yellow mouse that carries black or chocolate, and these latter pigments may even sparsely develop. It might seem, therefore, that it is the yellow that must disappear to produce a black mouse, and this, in fact, seems to be realized in the black-chocolate ticked mouse that I have described. If the ticking factor were then lost, pure black might result. It is possible that black mice may have originated in this way; but even were this true, it still remains not clear why the black should then spread into the chocolate region of the hair. Moreover, the sudden appearance of black animals in nature without an intermediate black-chocolate condition indicates that the transfer takes place at one step. These considerations seem to me to show that our assumptions are still too crude to offer a reasonable interpretation of the facts in hand.

THE ASSOCIATION HYPOTHESIS

If we suppose that black, chocolate and yellow and the ticking factor are carried by a common carrier in the gray mice, and that black is borne by a different (*i. e.*, not homologous) carrier in the black mouse, and chocolate by a third carrier in the chocolate mouse, we can not give a consistent hypothesis for the inheritance of these colors. For example, when gray is crossed with black, the presence of the triune body gives gray in the first generation. In the gametes of the gray hybrid, the gray carrier finds no mate on the hypotheses. Its allelomorph is therefore its absence. Similarly the black carrier has no allelomorph. The gametes will then be GB, GO, BO, OO. There would result twelve grays, three blacks, one white; but white mice do not result, as I have shown, from this combination. Moreover, they would contain no color determiner; and we know of no such mice.

It seems more reasonable, therefore, to assume that, if the three colors are combined in a single carrier, it may have lost successively one after another of its components as the black and chocolates arise. If we assume that by the dropping out of the yellow and the ticking factor a black mouse results, then gray would remain allelomorphic to black, since the material body carries one or the other. This is so far consistent with the results; but on the same hypothesis, chocolate is due to loss of black in the black mouse. If, then, gray is crossed to chocolate, not only should grays result in the F_1 generation, but only grays and chocolates in the second generation; yet Miss Durham has shown that grays, blacks and chocolates appear, which is inconsistent with the hypothesis. If, however, black and chocolate are stages in the development of the same substance, and the stage reached depends on another factor not present in the common carrier, but in another one, then the situation is clearer. Chocolate must be supposed to arise from black by the loss of this factor M, and since the factor is present in gray, then when gray is crossed to chocolate, the determiner for black is present as simplex, *i. e.*, once only. Its allelomorph is its absence. The formula for gray[6] would be (Y, Ch) M, and that for chocolate Ch. The formula for the hybrid will be, therefore, (Y Ch) M Ch. The allelomorphs are $\frac{\text{Y Ch}}{\text{Ch}}$, $\frac{\text{M}}{\text{O}}$, and the gametes (Y Ch) M, (Y Ch) O, Ch M, Ch O. Two such mice crossed will give twelve grays (including three cinnamon agoutis), three blacks and one chocolate, as the following table shows :

Y Ch M Y Ch M gray	Y Ch M Y Ch O gray	Y Ch M Ch M gray	Y Ch M Ch O gray
Y Ch O Y Ch M gray	Y Ch O Y Ch O cin.-agouti	Y Ch O Ch M gray	Y Ch O Ch O cin.-agouti
Ch M Y Ch M gray	Ch M Y Ch O gray	Ch M Ch M black	Ch M Ch O black
Ch O Y Ch M gray	Ch O Y Ch O cin.-agouti	Ch O Ch M black	Ch O Ch O chocolate

[6] Omitting the ticking factor from (Y Ch).

In the same way, the cross between yellow and gray would be represented as follows: If the yellow gamete is represented by Y and the gray gamete by (Y Ch) M, the resulting yellow mice would have the formula Y, (Y Ch), M; and its gametes would be Y, (Y Ch), M, and no M or O. The allelomorphs are then $\frac{(\text{Y Ch})}{\text{Y}}$, $\frac{\text{M}}{\text{O}}$; and the resulting gametes would be Y M, Y O, (Y Ch) M (Y Ch) O. The following table gives the composition of the resulting hybrids. There result twelve yellows to four grays. Now if the pure yellow combinations do not develop, as Castle suggests, *viz:* Y O Y O, Y O Y M (twice), Y M Y M, there will be left eight yellows and four grays, or 2 : 1.

Y M Y M yellow	Y M Y O yellow	Y Ch M Y M yellow	Y Ch O Y M yellow
Y O Y M yellow	Y O Y O yellow	Y O Y Ch M yellow	Y O Y Ch O yellow
Y Ch M Y M yellow	Y Ch M Y O yellow	Y Ch M Y Ch M gray	Y Ch M Y Ch O gray
Y Ch O Y M yellow	Y Ch O Y O yellow	Y Ch O Y Ch M gray	Y Ch O Y Ch O cin.-agouti

The "presence and absence" theory has been extensively used by modern writers on Mendelian inheritance. Bateson states that it gives consistent results in all cases so far studied, and he seems inclined, with some reservations, to adopt it as a method applicable to Mendelian treatment in general. Its usefulness and even necessity is apparent for many cases; but it does not seem to me, therefore, that it is advisable to extend it to all cases. If, as I have suggested, certain mutations result by or through the loss from certain material bodies that ordinarily carry a group of such bodies (such as gray, for example), the allelomorphs of the original body will be the new body, lacking the particular factor in question, and not the absence of the original body as a whole. The hypothesis of presence and absence appears originally to have been invented to explain the gray chocolate cross in mice. I have tried to show how the facts may be explained in a somewhat different way, so that the original combination for gray is allelomorphic with the factor for chocolate, while presence and

absence applies to another factor that concerns the change from chocolate to black. A combination of the two hypotheses seems to me to be more useful than the adoption of either alone. Moreover we can see, on the view of the allelomorphic relation of the factors that I have used here, why in some cases one and in other cases the other way of expressing the facts should be used.

UNIT CHARACTERS AND FACTORS IN MENDELIAN INHERITANCE

I understand by the term unit character any particular structure or function that may appear in heredity independent of other characters. Such unit characters may in themselves be extremely complex and include the possibility of further splitting up. By factor I understand some special condition in the germ plasm whose presence is necessary for the development of a particular unit character which in its absence fails to develop. There is unquestionably a tendency in much of the Mendelian writing to identify the unit character with one only of the factors whose presence is necessary for its development. This view seems to be as unnecessary in the present state of our knowledge as it is unproven by the evidence at hand. It is this point of view that underlies the entire Weismannian conception of the process of heredity. The acceptance of the theory of factors does not seem to me to lead necessarily to such a conclusion; for, while a factor may be essential to the development of a particular part, it may be only one condition, several or many conditions combining to produce the effect, the absence of any one of them leading to the same result. Thus, while it may be that a particular chromosome or a small part of a chromosome is essential for the formation of a unit character, it may be that all the other chromosomes and all or many of the elements that constitute the cell also take part in the final elaboration of the special organ in question. This may represent the extreme case, and there may be all degrees in which different parts of the cell combine to produce any given organ. The essential point is that the acceptance of the factor hypothesis in heredity by no means leads to the conception of each character being located in a special unit or biophore or pangene in the egg, for, as I have said, many parts may be equally essential for the production of every part.

Concerning the mechanism of segregation in the germ-cell we know very little at present. Many facts seem to point to the conclusion that the simplest solution of segregation is that a sorting-out of material particles takes place during those processes that come under the general head of maturation in the egg or spermatozoon. This sorting process involves

the units or factors, and most of those who have written on the subject give the impression that this sorting involves the actual materials out of which each character is built up. I do not think that we are justified in this interpretation of the factor hypothesis, for all the facts can be equally well explained, if the material particles sorted in maturation represent only parts of the material basis, whose entire activity is essential for the formation of parts of the organism. The difference in point of view is, I believe, fundamental, even if the practical outcome is the same, for our entire conception of the mechanism of heredity and development is involved.

On another occasion[7] I have discussed the view as to how far the mechanism of segregation in the germ cells is comparable to the processes that take place in the later development of the egg itself, when different regions develop into different parts at the time of the specification of the organs and tissues. I pointed out that there is a good deal of analogy to support the view that the two processes are the same. The Weismannian conception practically identifies the two processes, for the biophores are supposed to be sorted out in the maturation process in the same way that they are sorted out as the development of the embryo proceeds.

On the one hand, if the facts lead us to interpret the process of segregation as due directly to a separation during the process of maturation of material particles (factors) essential for development of particular organs, on the other hand the facts of experimental embryology and of regeneration have seemed to experimental embryologists to speak equally emphatically in favor of the view that the localization factors are essentially different from those assumed for Mendelian segregation.

An examination of the facts of sex-limited inheritance has seemed to me to show with some probability that the simplest conception of the mechanism of segregation is that material particles carried in the chromosomes are separated at these divisions and lead to the Mendelian classes of gametes. I do not deny that the facts may be conceived as due to other kinds of processes that lead to the formation of two classes of gametes for each pair of allelomorphs, but when we take into account the evident random segregation of the factors any other hypothesis than that based on particulate separation seems to me far more improbable than the one here suggested. If this is admitted, the next logical step would seem to require a similar process in development of the embryo. I need only mention by way of example the occasional appearance in heterozygous individuals of the dominant and the recessive characters in different parts

[7] American Breeders' Association, V, 1909.

of the body, as when one eye of a mouse is black and its mate is pink, or one wing of *Drosophila* is long and the other short.

It may therefore be worth while, perhaps, to attempt to recast our conception of development in the light of these facts. Obviously it may not be necessary to attempt to explain all embryonic phenomena as due to segregation. There are several facts of experimental embryology that seem to indicate that there are other relations between the cells that are important factors in determining their fate, but the essential facts of specification and differentiation may nevertheless be explained by the particulate theory. No fact is more evident than that in most cases a region once determined has lost its power to produce other parts, and this fact bears a strong resemblance at least to the segregation process in the germ cells that produce recessive characters.

This argument may seem to lead back to Weismann's theory of development, but it differs from his view in two essential respects: *Firstly,* it admits that development involves not only a process of separation of particles, but that other factors also are involved, especially those that regulate the symmetry of the body and its parts. *Secondly,* it does not look upon the particles of chromatin as each representing a different part of the body—of its characters, in short—but for the development of each part certain parts of the complex of particles form the necessary foundation and for other parts other complexes. The germ material from this standpoint loses in the course of development now one, now another, of its materials, and the absence of these materials is responsible for what each region can produce. Weismann's view postulates the presence of particular particles that produce each part. On his view, each part has a representative in the original germ plasma, while on the view here suggested, most of the entire material is necessary for the development of each part, but the loss of one or another particle of the chromatic complex turns the developmental processes into different channels. I am aware that speculation concerning the processes of development and Mendelian segregation may seem premature at present, but I can not but think that it may be worth while to attempt to bring under the same point of view the process of gametic segregation and the processes that take place in the development of the embryo.

Literature

Allen, G. M. Heredity of coat color in mice. Proc. Amer. Acad. Arts and Science, XI. 1904.

Bateson, W. Mendel's principles of heredity. Cambridge. 1910.

Castle, W. E. Yellow mice and gametic purity. Science, XXIV. 1906.

Castle and Allen, G. M. The heredity of albinism. Proc. Amer. Acad. Arts and Science, XXXVIII. 1903.

Castle, W. E., and C. C. Little. On a modified Mendelian ratio among yellow mice. Science, XXXII. 1910.

Cuénot, L. L'hérédité de la pigmentation chez les souris. Arch. de Zool. Exp. et Gén. 1902, 1903, 1905, 1907.

———. Sur quelques anomalies apparentes des proportions Mendeliens. Arch. de Zool. Exp. et Gen. IX. 1908.

———. Recherches sur l'hybridation. Fourth Inter. Zool. Congress. 1907.

Darbishire, A. D. Note on the results of crossing Japanese waltzing mice with European albino races. Biometrika, II. 1902.

Davenport, C. B. Color inheritance in mice. Science, XIX. 1904.

Durham, F. M. A preliminary account of the inheritance of coat-colour in mice. Report Evolution Committee, IV. 1908.

———. Note on Melanins. Jour. Physiol., XXXV. 1907.

Hagerdoorn, A. L. Inheritance of yellow color in rodents. University of California Publications in Physiology. 1909.

———. Mendelian inheritance of sex. Archiv. Entw. mech. der Organismen, XXVIII. 1909.

Morgan, T. H. The assumed purity of the germ cells in Mendelian results. Science, XXII. 1905.

———. Are the germ cells of Mendelian hybrids pure? Biol. Centralb., XXVI. 1906.

———. Some experiments in heredity in mice. Science, XXVII. 1908.

———. Breeding experiments with rats. American Naturalist, XLIII. 1909.

———. Recent experiments on the inheritance of coat colors in mice. American Naturalist, XLIII. 1909.

———. What are factors in Mendelian explanations? American Breeders' Association, V. 1909.

———. Chromosomes and heredity. American Naturalist, XLIV. 1910.

Wilson, E. B. Mendelian inheritance and the purity of the gametes. Science, XXIII. 1906.

PLATE VII

CHANGES IN COAT COLORS OF MICE

Fig. 1. No. SW. A heterozygous mouse showing dilute and chocolate areas.

Fig. 2. No. 32½. A heterozygous black-chocolate mouse showing areas of black, chocolate and lighter chocolate (mixed).

Fig. 3. No. PC. A heterozygous black-chocolate mouse with "ticked" hair.

Fig. 4. No. D[1]. A black-chocolate heterozygous mouse.

1

PLATE VIII

CHANGES IN COAT COLORS OF MICE

Fig. 1. No. NMA. A hybrid out of a black-gray (extracted) cross.

Fig. 2. No. AAbb. A heterozygous white-bellied gray showing light gray and some gray areas.

Fig. 3. No. NMA. A heterozygous mouse showing black and gray areas.

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2

3

PLATE IX

CHANGES IN COAT COLORS OF MICE

Peromyscus leucopus ammodytes from Monomoy Island showing the normal light color peculiar to many individuals of this race.

Another mouse of the same stock that had been kept in confinement and had changed for the most part to a light, almost white, color.

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ON SOME NEW GENERA AND SPECIES OF PENNSYLVANIAN FOSSILS FROM THE WEWOKA FORMATION OF OKLAHOMA[1]

BY GEORGE H. GIRTY

CONTENTS

INTRODUCTION

Geographically the Wewoka formation is typically exposed in the northwestern portion of the Coalgate and the southwestern portion of the Wewoka quadrangles of Oklahoma. Lithologically it consists of alternating bands of sandstone and shale,—four sandstone and three shale members—and it has a thickness of about 700 feet.[2] Geologically the Wewoka formation is part of the Pennsylvanian series and in the Oklahoma section lies above a considerable thickness of Pennsylvanian rocks, but it probably correlates with the lower portion of the Pennsylvanian section of Kansas.

The fauna of the Wewoka formation, so far as known, occurs in the two lower shales, from which the fossils weather free and for the most part in an unusually perfect condition of preservation. The fauna is highly differentiated, comprising not less than 148 species, and it is not

[1] Published by permission of the Director of the United States Geological Survey.
[2] U. S. Geol. Survey, Geol. Atlas, Folio 74. 1901.

confined chiefly to the brachiopoda like so many Carboniferous faunas, but presents all the zoological groups in just proportion. The greater part of the fauna, as one would expect, consists of species already in the literature, but a considerable number of new forms, both genera and species, have been obtained. These are described below, but a report containing descriptions and figures of the entire fauna has been completed and submitted for publication as a bulletin of the United States Geological Survey.

Descriptions of Genera and Species

Protozoa

Fusulina inconspicua sp. nov.

Shell small, sub-cylindrical to somewhat fusiform. The average length is perhaps 3 mm., with a diameter of about 1 mm., but specimens 3.5 mm. long are not uncommon. A few have a length of 4 mm., while one example provisionally referred to this species is nearly 5 mm. long and 1.5 mm. in thickness. Different specimens vary appreciably in proportions, some being slender and others more robust. As is common in this genus, young specimens are relatively more slender than mature ones. For the most part, this species is of very regular growth with a sub-cylindrical shape abruptly rounded at the ends. Some specimens taper more distinctly than others. In general, this appears to be an immature character, appearing in young shells more than in mature ones and being retained to a later stage in some than in others.

Initial cell rather large, about .1 mm. in diameter. The largest measured had a diameter of .11 mm., others .099 mm., still others .084 mm., and others even smaller. It seems reasonable to infer that the initial cell varies in size in different specimens, but that the smaller measurements are in many cases due to the section not passing through its center. The walls are thin, the septa and outer wall being nearly equal in thickness. The specimens studied do not show the minute structure. In mature specimens (1 mm. in diameter) five or even six revolutions of the outer wall can be counted in addition to the initial cell. In a mature specimen (1 mm. in diameter) some 23 septa occur in the outer volution, and this appears to be about normal. The specimens examined may not show this character with accuracy, but the sutures or superficial lines formed by the septa are indistinct and not depressed. They are straight or nearly straight at the surface, but a little below, the septa appear to become strongly plicated.

Height of final chamber about .07 mm. or .08 mm.; thickness of the outer wall about one third to one fourth as much, or .028 mm. to .02 mm.

This diminutive species, which occurs in great numbers at the one horizon in the Wewoka formation where it is found at all, is readily distinguished from all other American species thus far known, by its much

smaller size, and from some of them by its elongated and cylindrical instead of fusiform shape. In size, it resembles the European *F. minima*,[3] but is somewhat larger, more slender in shape, and less fusiform. The shape is suggestive of *F. lutugini* Schellwien[4] and *F. longissima* Möller,[5] but the size is very much smaller.

Horizon and locality: Wewoka formation; Coalgate quadrangle, Okla.

Spongiæ

Wewokella gen. nov.

The general shape of the present form is that of a cylinder with a large tubular cloaca. No dermal layer has been observed. The walls are rigid and made up of large spicules interlaced with one another. The typical spicular element appears to be the tetraxon, but many spicules do not show this shape and appear to be elongated, irregularly branched and more or less contorted. In general, however, the trend of the spicules is longitudinal.

The form for which this title is introduced is rare in the Wewoka formation, only two specimens having come to hand. They might perhaps be referred to the genus *Doryderma*, were it not for the fact that they indicate a form which has a large central cloaca instead of a number of axial canals, and in which the radial canals of *Doryderma* are also apparently wanting. The general relationships of the type are nevertheless supposed to be with that genus, which has also been cited from Carboniferous strata.

Type species, *Wewokella solida*.

Wewokella solida sp. nov.

Sponge body irregularly cylindrical, attaining a diameter of at least 25 mm. Center occupied by a large tubular cloaca, the walls being about 7 mm. thick and showing no evidence of being pierced by radial canals. If a dermal layer was originally present, it has been lost. The walls now are made up of large spicules, of which the typical shape is probably 4-rayed with one of the rays more or less elongated. At the same time, some of the rays may be aborted so that many of the spicules seem to be irregularly branched. They are so interwoven as to make up a wall of considerable rigidity, to aid in which the spicules may be partly cemented, although it is doubtful if they anastomose. The structure, then, while very varied in detail makes on the whole a homogeneous wall which apparently is the same on the inside as on the out. Among the large spicules are other tetraxons of conspicuously smaller size.

Horizon and locality: Wewoka formation; Coalgate quadrangle, Okla.

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[3] Palæontographica, vol. 55, p. 167, pl. 13, fig. 23. 1908.
[4] *Idem*, p. 177, pl. 17, figs. 2, 3, 7, 8, 12-14.
[5] *Idem*, p. 163, pl. 13, figs. 14-20.

Cœlenterata

Lophophyllum profundum var. **radicosum** var. nov.

Associated with individuals having the character of *Lophophyllum profundum*, occur other specimens which differ strikingly in the profuse development of hollow, spiniform stolons. Correlated with this character are usually a more rapid expansion, a more irregular growth, a rather straighter shape and the possession of a thinner, more knife-like pseudo-columella. The stolons which are usually broken off close to the epitheca, disclosing their tubular structure, are especially developed in the lower portion of the corallum. It seems doubtful whether these structures served primarily for support, since they are found in specimens having an unusually broad and secure attachment and are absent from others in which the point of attachment is small, and the anchorage apparently insecure.

The stolons vary from large and very abundant to small and reduced to only one or two in number. In this way, a gradual transition is effected between the two forms which in their extreme expressions look very much unlike each other, while among intermediate and less strongly characterized specimens, a dividing line can hardly be drawn. The forms with more or less straight, irregular, rapidly expanding coralla graduate on the one hand into those with very abundant stolons, and on the other into the narrow, more or less curved, regular coralla of typical *profundum*. It seems to be true, however, that the narrow, regular growths seldom exhibit any development of the root-like process.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Echinodermata

Hydreionocrinus patulus sp. nov.

This species is based on a somewhat imperfect calyx which is distinguished by its low convexity. The median portion of the under side is strongly concave and the height of the whole is but little greater than the thickness of the plates. These peculiarities may, however, be somewhat enhanced by compression.

The general shape is pentagonal, with angular notches at the corners and a wider irregularity at the azygous angle. The plates themselves are thick and they are highly tumid on the outer side. They tend to recurve near the margins so that the sutures are not as depressed as the general curvature of the surface, if continued to the edges, would make them. The plates near their margins tend to be rather regularly and finely crenulated and the infra-basals and adjacent portions of the basals are finely granulose. Unless lost through erosion, these markings do not extend to the other plates.

The infrabasals form a small pentagon of which the radius of the scar of the stem occupies half the distance from the center to the side. The scar is

small, crenulated about the circumference, and with a diminutive round axial canal. The basals are irregularly hexagonal, shaped more like a triangle with its basal angles truncated. That to the right of the azygous plates is slightly larger than the others and not symmetrical.

The radials are seven-sided, twice as wide as high, the base of the heptagon being uppermost and very long. The two apical sides are also long and somewhat concave, while the two lateral sides are short. The two plates near the azygous group are unsymmetrical, and have the apical sides of unequal length. Just below the upper margin of each of the radials occurs a short slit-like excavation. Above this on the broad upper side of the plate, there is a triangular depression defined by two elevations or ridges which also bend outward and extend along the outer margin of the upper surface. A somewhat similar triangular excavation marks the inner side of the upper edge of the thick plate.

The azygous basal is subquadrate, much longer than wide, in reality being 7-sided with a relatively broad base. The sides are formed by a broken line of which the lower portion is much shorter than the upper. The upper side is also made by a broken line, the dextral part of which is long and oblique and the sinistral short, merely truncating the angle which the other would otherwise make with the left side. This plate is therefore bounded below by the infrabasal, on the right and left sides by the basal and the radial, and on the upper side by the two other azygous plates. The second and third azygous plates are missing from the specimen, as are also the brachials.

Hydreionocrinus patulus resembles *H. discoidalis* and *H. crassidiscus.* From the former it may be distinguished by its larger size, more convex plates, granulose surface and by the shape and arrangement of the azygous plates. The azygous basal in the present species is differently shaped, so that it is in contact at the right with the radial, thus separating the second azygous plate from the adjacent basal on that side.

The relationship with *crassidiscus* is rather more close. The basals ("subradials") are however described as all hexagonal, while here they are five-sided, except the azygous one, which is seven-sided. The azygous basal does not in *crassidiscus* reach the second basal "as is usual in this genus." Furthermore, in the present species, the second azygous plate intervenes between the first and the radial to the right.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Annelida

Enchostoma serpuliforme sp. nov.

Attached to a large undetermined Orthoceras are some slender tubular organisms seeming to belong to the genus *Enchostoma.* One, from which the present description is drawn, has a diameter of 1 mm. or less and winds about on the Orthoceras to a length of almost 140 mm., without appreciably

increasing its diameter. Neither the initial point nor the true aperture appears to be shown. The cross-section must have been nearly circular. The shell substance, when preserved, is lamellose, phosphatic, of a light bluish color and in places distinctly nacreous. For the most part, however, the shell appears to be missing and only the muddy infilling of the tube remains, of a rusty color and partly with a dark limonitic coating. Where the entire organism is removed, its place is represented by a groove. As the original test of the Orthoceras is now absent, this impression naturally occurs on the mold of the inside and the explanation of the phenomenon is difficult. I think we can not assume that the organism was originally attached to the inside of the Orthoceras, because of the septa. It may, however, have been attached to the outside or have been partly imbedded in the shell, through the gradual solution of which these external bodies, insoluble under prevailing conditions, were brought into contact with the mud which filled the interior. This hypothesis, however, is unsatisfactory, because the specimen is not bent but broken by the compression which it has suffered, showing a rigid condition at the time the force was applied.

The shape and phosphatic appearance of this organism are characteristic of *Enchostoma*, but such Enchostomas as I have heretofore seen are free and of larger size. The small size, sessile condition, and probably false appearance of having been partly imbedded in the shell of its host, are very suggestive of the organism which I have here called *Serpulopsis insita*, but none of the specimens of *Serpulopsis* shows any evidence of having had a phosphatic shell. They are also small and very much shorter. The true relationship of this form and its position in the animal kingdom remain problems as yet unsolved.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Serpulopsis gen. nov.

This name is introduced for some small tubular organisms which enlarge very gradually and are frequently much contorted during part of their growth. They have the habit of attachment to other organisms and are more or less imbedded in the shell of their host. They always keep near the surface, but are perhaps as seldom completely superficial as they are completely imbedded.

I can scarcely doubt that the fossils on which this genus is founded belong to White's *Serpula insita*, which, consequently, is taken as the type.

Serpulopsis is distinguished from *Serpula* by its burrowing habit, which is in fact abnormal for the annelids. Even if the excavations alone and not the tubes which ordinarily occupy them were known, it would be impossible to refer these structures to the boring sponges which they somewhat suggest, because of their strictly superficial, linear and not inosculating character. In some respects, they suggest *Rhopalonaria* among the Bryozoa, but, while specimens frequently occur together in considerable numbers, they appear to form groups of independent indi-

viduals and not colonies, nor is there any evidence that the individual tubes were composite. On the whole, therefore, it seems more probable that this fossil was an abnormal type of annelid.

Type species, *Serpulopsis insita.*

Conularia crustula var. holdenvillæ var. nov.

A few specimens from the Wewoka agreeing in a general way with *C. crustula* differ in having the sculpture on a much finer scale. Unlike typical *crustula* also, these specimens are more or less compressed and distorted, the other form which aparently had an unusually thick rigid test not having suffered much in that way. About 25 costæ occur in a linear distance of 5 mm., and thus they are much more closely arranged than in the typical form.

Among the specimens examined this variety is readily distinguished by its sculpture, the difference being so marked that it seems desirable to discriminate it as a new variety if not as a new species. It may possibly be a young stage of *C. rœperi,* the only other Pennsylvanian *Conularia* which has been described, although this form tapers more rapidly than *C. rœperi*, which has nearly parallel sides.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Brachiopoda

Rœmerella patula sp. nov.

Shell rather small for the genus, rarely exceeding 18 mm. in diameter, though in one instance reaching nearly 30 mm. Shape slightly oval in some specimens, apparently circular in others.

Convexity of dorsal valve low, regular. Apex small, slightly though conspicuously eccentric, situated about two thirds of a radius from the posterior margin. Outline from the apex to the front slightly curved, so that the shape is not truly conical, being somewhat inflated in the apical portion.

Curvature of the ventral valve usually compound, more or less strongly convex over the posterior portion and more or less strongly concave at the front and sides. The prominent portion projects above the reflexed rim. The point of highest convexity is usually well marked and is situated diametrically opposite to that of the dorsal valve, or about two thirds of a radius forward from the posterior margin. On the slope posterior to the point of greatest elevation the pedicle fissure is situated. It is a conspicuous feature, rather long and narrow, with strongly introverted sides. It extends in mature shells from the point of greatest elevation half way to the posterior margin and is surrounded without interruptions by the characteristic sculpture.

The sculpture, as usual, consists of narrow, sharply raised concentric liræ with considerably wider, flattened interspaces, which are also finely striated. The liræ are somewhat irregular and are probably stronger and more persist-

ent on the ventral than on the dorsal valve, on which they are often evanescent about the margins for a greater or less distance. They vary considerably in different specimens, being more closely arranged in some than in others, occurring from nine to eleven in 3 mm. They also vary on the same specimen in proportion to their distance from the apex, and are more crowded on the posterior than on the anterior side; consequently, the measurement given above is a relative one, representing the condition toward the front in well-grown specimens. Exfoliation obliterates much of the concentric marking and instead often brings to view fine radial lines and striæ, probably due to setæ which projected from the margin of the shell.

On the interior, the dorsal valve has a short septum passing longitudinally through the apex, and extending farther on the anterior than the posterior side of it. There are also two symmetrical ridges, straight, parallel and close together for some distance anterior to the apex, rapidly diverging and somewhat curved near it, so as partly to surround it. Between the straight extended anterior portion of these arms there is a medium groove which extends backward and graduates into the septum, which has depressed sides. The curved arm-like markings probably represent the boundary of a line of muscular attachment. In one specimen these lines are, near the apex, distinctly expanded into oval areas, one on each side, each of which is separated by an oblique line of division into two scars. These areas, without much question, are the loci of pairs of muscles.

The internal markings of the dorsal valve described above are conspicuous on most of the specimens examined, which are usually preserved as internal molds. They vary in detail in different examples. This peculiar structure seems to be identical with that upon which Hall and Clarke based the subgenus *Rœmerella*, and while there may be a little doubt as to whether it is really of subgeneric value, it will, together with the configuration, readily distinguish this form from other Pennsylvanian discinoids. Some specimens, especially if incompletely exfoliated, fail to show this structure, however.

Rœmerella patula is rather abundant in the Wewoka formation and usually occurs as dissociated valves in small concretions. Occasionally, however, the two valves are found in conjunction, though usually more or less displaced.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Streptorhynchus oklahomæ sp. nov.

There are in the Wewoka collection two specimens which appear to belong to the genus *Streptorhynchus*. They are preserved as internal molds and show dental callosities in the ventral valve without any trace of a septum. In the dorsal valve, the socket plates are fairly well developed and one specimen has a low dorsal septum. In point of convexity the dorsal valve is only gently

convex, the ventral rather high and more or less contorted. The shell contracts at the hinge, the area being moderately high and strongly inclined backward. The sculpture consists of fine, regular, subequal liræ (in one specimen more or less distinctly alternating). In the type specimen the liræ are equal over the median portion and separated by intervals slightly greater than their own width. Here they occur ten in 5 mm. Toward the sides they are rather more distantly spaced and are alternating.

The rarity of this genus in our Pennsylvanian rocks constitutes an *a priori* argument against these specimens belonging to *Streptorhynchus*. On the other hand, it is difficult to understand how the process of fossilization, while permitting the dental callosities to be preserved, could obliterate all trace of the septum.

Horizon and locality: Wewoka formation; Coalgate quadrangle, Okla.

Chonetes granulifer var. armatus var. nov.

The fossils included under this title occur associated with *C. mesolobus* var. *decipiens*, and with the more closely related *C. granulifer*. They are of small size, 15 mm. being the maximum width observed, of moderate convexity where not compressed, subquadrate shape, rather prominent beak, and faint though distinct insinuation. About seven cardinal spines occur on each side of the beak.

The surface is marked by obsolescent liræ and by numerous small though prominent spines.

This variety is distinguished from *C. granulifer* by the smaller and less projecting beak, the nearly obsolete liration, and the number and prominence of the spines, although the latter character may be to some extent the result of preservation. With the evidence at hand, however, I would not feel justified in regarding these shells as true representatives of *C. granulifer*.

Horizon and locality: Wewoka formation; Coalgate quadrangle, Okla.

Chonetes mesolobus var. decipiens var. nov.

1899. *Chonetes mesolobus*. GIRTY, U. S. Geol. Survey, Nineteenth Ann. Rept., pt. 3, p. 576.
Upper Coal Measures: Atoka quadrangle, Oklahoma.

1903. *Chonetes mesolobus*. GIRTY, U. S. Geol. Surv., Prof. Paper 16, p. 357, pl. 1, figs. 20–23.
Hermosa formation: San Juan region, Colo.
Rico formation: San Juan region, Colo.
Maroon formation: Crested Butte district, Colo.
Carboniferous: Grand River region, Colo.

This form differs from typical *C. mesolobus* in having a smooth instead of striated surface. Though I was at first disposed to describe it as a new species

rather than a new variety, the lower taxonomic rank is probably more in accordance with the facts.

The peculiar configuration of *C. mesolobus* is known to everyone. The typical form is described as possessing fine, radiating striæ. Some well-preserved specimens from Ohio show this feature very clearly. The liræ are fine and moderately strong and they give rise to a large number of minute spines, a feature not mentioned by Norwood and Pratten, though it is perhaps represented by one of their figures. Mr. Beede[6] also appears to record it when he describes the surface as "coarsely punctate." He may, however, be referring to another and an altogether different feature, to more numerous perforations, which occur between the liræ instead of on them and which project as rows of spinules or pustules on the inside of the shell. These are best shown on exfoliated specimens or internal molds. The external feature to which I refer above has, also, when the shell is worn, the appearance of punctæ, but when better preserved, the punctæ show projecting edges as of downward pointing spines, very similar to the minute spines which are found on many orthoids.

The variety which is the subject of this account has the characteristic configuration of *C. mesolobus*, but the surface is entirely without radiating sculpture, marked only on the best specimens by fine growth lines. The absence of radial striation is not due to erosion or any circumstance of fossilization, for it is a persistent feature shown by an extensive series of specimens from many localities. Furthermore, the radial markings could hardly have been lost, when the more delicate growth lines had been retained.

In characteristic specimens, this difference is so strongly marked that one would be led to refer the two forms to altogether different groups, and as already noted, I was at first disposed to regard them as distinct species. When large series of specimens from different horizons are examined, however, individuals more or less intermediate in character are found. That is, associated with the smooth variety are occasional shells which show faint yet unmistakable traces of radial sculpture. Such specimens must be carefully examined, however, to determine whether this character is not adventitious, for under exfoliation the rows of internal spinules which have oblique pores connecting with them form little grooves and produce fine, more or less regular radiating markings.

The shells belonging to the smooth variety rarely show traces of the spines found on the other. Except for occasional incremental lines the surface usually appears to be quite featureless.

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[6] University Geol. Surv. of Kansas, Rept., vol. VI, p. 71. 1900.

C. mesolobus var. *decipiens* is very abundant in the Wewoka formation. It is also abundant in some of the earlier Pennsylvanian deposits of the Kansas section at about the horizon of the Parsons formation.

In the literature, no citation can definitely be included in the synonymy except my own identifications of specimens obtained in Oklahoma and in Colorado. I remarked in that connection that the Colorado specimens were characteristic in every way, but I had for comparison not typical, striated *C. mesolobus*, but specimens of the present variety.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Chonetes mesolobus var. euampygus var. nov.

Considerable variation is shown by shells of the *mesolobus* group in the strength with which the characteristic lobation is developed. In some of the larger individuals especially, it can hardly be distinguished at all, and when, as is usually (?) the case, such specimens belong to the smooth or *decipiens* type, they simulate *C. geinitzianus* very closely. It is at least possible that *C. geinitzianus* may have had this derivation, though one would have said *a priori* that such phylogeny was of all the least probable.

It is probably true as a general statement, though not without exceptions, that the strength of the lobation varies inversely as the size of the individual. There is at all events a group of shells which stand out strongly and distinctly by reason of their small size and deep lobation. That they are mature shells is indicated by their strong convexity and by the fact that young individuals of the larger form would be more faintly lobed. Though they intergrade with the larger, less strongly lobate shells through larger examples which have an almost equal strength of lobation, they form a distinct, and as a rule an easily discriminated group which sometimes occurs alone to the exclusion of the typical variety. In sculpture, these shells seem to be allied to the variety *decipiens*. They are usually unstriated, but show traces of striæ more frequently than *decipiens*. Seldom, if ever, is the striation as strong as in well-characterized specimens of *C. mesolobus* s. s.

None of the specimens referred here exceeds 10 mm. in width, and the average is nearer 7 mm.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Productus insinuatus sp. nov.

1892. *Productus æquicostatus*. Hall and Clarke, Geol. Surv. New York, Pal., vol. 8, pt. 1, pl. 17 A, figs. 22, 23.
Coal Measures: Nebraska.

1892. *Productus æquicostatus*. Hall and Clarke, State Geologist New York. Eleventh Ann. Rept., for 1891, pl. 22, figs. 11, 12.
Coal Measures: Nebraska.

1894. *Productus æquicostatus.* HALL and CLARKE, "Introduction to Study of Brachiopoda," pt. 1, pl. 22, figs. 11, 12.
Coal Measures: Nebraska.

1900. *Productus cora* var. *americanus.* BEEDE, Univ. Geol. Surv. Kansas. Rept., vol. 6, p. 77, pl. 11, fig. 2.
Upper and Lower Coal Measures: Kansas City, Eudora, Anderson Co., Kansas.

1906. *Productus cora* var. *americanus.* WOODRUFF, Nebraska Geol. Surv., Rept., vol. 2, pt. 2, p. 270, pl. 11, fig. 2.
Carboniferous: Louisville, Nebraska.

Shell of the *cora* type, rather large, widest at the hinge, more or less strongly transverse. In the immature condition, this form closely resembles *P. cora* itself, being strongly convex and more nearly quadrate. In the later stages, the growth is more spreading, especially at the sides, and the margins are flatter. Two varieties can be distinguished, one which is narrow and more highly arched and the other transverse and less convex. In the mature condition, also, the ventral valve becomes elevated and angular along the median line. Correlated with this character is an inflection of the anterior margin making a deep sinus in the outline. A sinus or depression in the shell itself is naturally absent.

The surface is marked by fine, even, rigid, rounded costæ having the peculiarities of those of *P. cora*. As in that species, the costæ bifurcate freely and sometimes this takes place simultaneously all around a shell, so that for a time the striation is much finer about its margin than over the earlier portion. In connection with the carina, the costæ in the immediate neighborhood frequently bend inward toward the median line which in some cases appears to have been without costæ. A few large plications are found at the sides near the hinge, but they seldom pass entirely across the shell. They are apt to be more persistent on the dorsal valve, however, than on the ventral. Spines are scattered over the surface of the ventral valve, but they are usually small, not causing nodes on the costæ, and they are liable to be overlooked when broken off. They appear to be few in number. A row of larger ones is developed along the cardinal line.

As the synonymy shows, this species has several times appeared in the literature under the title of *Productus æquicostatus*, but a careful reading of Shumard's description leaves little doubt that *P. æquicostatus* was a different species and one more closely similar to *P. cora* itself.

Horizon and locality: Found in the Wewoka formation, but the type specimens are from Kansas.

Pugnax osagensis var. **percostata** var. nov.

This form is more abundant in the Wewoka formation than the typical variety. In a general way, the specimens referred here agree with *P. osagensis*, the only difference of importance being the more numerous plications which are also smaller and more angular. Of these there are usually five fairly

strong on each side, but there may be four or six. Three is the usual number for the fold, but four and even five occur in rare instances. Individuals with three mesial plications and four laterals, especially when one or two of the latter are immature or imperfectly developed, might equally well be placed under *P. osagensis* itself. Apparently this variety has been referred by authors to *osagensis* unqualifiedly, but I believe it can be distinguished to advantage.

This form resembles *P. osagensis* var. *occidentalis*, which is, however, a much larger species, with on the whole, more numerous mesial plications, and it occurs in very different faunal associations.

Horizon and locality: Wewoka formation; Coalgate quadrangle, Okla.

Pelecypoda

Nucula wewokana sp. nov.

Shell small, triangular; width slightly, though distinctly, greater than the height. Beaks set well toward the posterior end, toward which they more or less distinctly point. The convexity is high. The cardinal and posterior ends are abruptly flattened or depressed into a usually well-defined escutcheon and lunule. The ventral border is regularly rounded. The anterior and cardinal lines are straight or gently convex according as the lunule and escutcheon are flat or project somewhat from the abrupt infolding of the shell along the two edges. The anterior end is strongly rounded; the posterior is subangular.

The surface is finely, sharply and regularly striated.

This species is related to *N. parva* McChesney, with which, in fact, I at first identified it. It differs, to judge by the figures of McChesney and of Meek and Worthen, in being less transverse and in having the shell at the posterior or shorter end less strongly projecting. *N. wewokana* is also very similar in outline to *N. pulchella* Beede and Rogers, but *N. pulchella* is said not to have a distinct lunule and the posterior end seems to be abruptly truncated. In the present species, the shell projects a little, so that the outline at this end is usually gently convex and formed by the edge of the shell, whereas in *N. pulchella*, it is straight and formed by the angle of flexure, which either overarches the margin or is coincident with it when viewed from above.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Anthraconeilo subgen. nov.

The shells included under this title are rather large, strongly transverse, very inequilateral, considerably produced anteriorly. The beaks point toward the shorter side. Shell closed all around. Dentition taxodont with a great many

small teeth on the anterior side and a few large teeth on the posterior. Chondrophore probably present but not observed. Anterior and posterior scars large. Probably two other smaller scars are situated near the hinge, one in front of and the other behind the beak, between it and the anterior and posterior scars. Pallial line apparently entire or with only an obscure sinus.[7] Sculpture consisting of fine regular concentric striæ.

This type in general appearance is intermediate between *Nucula* and *Leda*. From *Nucula* it differs in its transverse shape and produced anterior extremity. From *Leda* it differs in having the beak directed toward the short side, which is probably posterior as in *Nucula*. The muscle scars seem to be much as I have observed them in *Leda bellistrista*, but there is no oblique internal ridge crossing the umbonal region, and the arrangement of the teeth, chiefly to one side of the beak, is another conspicuous difference. This type also much resembles *Paleoneilo*, from which it differs in lacking an external ligament and being without the sinus, developed in the inferior contour and in the lines of sculpture. The latest species which can with safety be referred to *Paleoneilo* occur in the early Mississippian. *Anthraconeilo* differs from *Yoldia* in not gaping behind and in having the beak directed toward the shorter side.

In addition to the type species described beyond as *Anthraconeilo taffiana*, there can probably be transferred to this group three species at present included under *Yoldia*, viz: *Y. carbonaria*, *Y. knoxensis* and *Y. oweni*. The two latter differ from *Yoldia* and agree with *Anthraconeilo* in having the beaks turned toward the short side of the shell, and their inclusion in the latter is regarded as probably correct. The case of *Y. carbonaria* is more doubtful, since it seems presumptuous to suppose that so excellent a conchologist as Meek would assign to *Yoldia* a shell in which the beaks pointed toward the short side, whereas, if they point toward the long side, *Y. carbonaria* is clearly not a representative of *Anthraconeilo*. Even if the beaks point toward the long side, however, I should somewhat doubt the correctness of his reference to *Yoldia*, on account of the convexity of the shell and the prominence of the beaks.

Type species, *Anthraconeilo taffiana*.

Anthraconeilo taffiana sp. nov.

Shell rather large, transverse. Width nearly twice the height. Shape subelliptical. Posterior end strongly and symmetrically rounded. Dorsal border long, rectilinear. Ventral border convex, more strongly curved toward the posterior end, subrectilinear anteriorly. Anterior end produced, more or

[7] If a sinus is really present, the orientation here employed should be reversed; the long side is posterior and the beaks point forward, toward the short side.

less symmetrical, somewhat truncated at the narrow extremity. Greatest height about one third the shell length in front of the posterior margin. Convexity rather high, chiefly situated in the posterior third of the shell; compressed anteriorly, somewhat compressed near the posterior margin as well. Beak small, strongly incurved, pointing toward the short end of the shell.

Surface not well shown, often apparently smooth. A few examples are marked by regular, closely arranged concentric striæ, and many show more prominent irregularities of growth.

The dentition consists of about six large posterior teeth and about 30 small anterior teeth. An interval beneath the beak is probably occupied by a number of additional teeth of small size.

There is the usual complement of large muscle scars, one anterior and one posterior, situated near the dorsal border. Apparently a small elongate scar occurs between the anterior adductor and the beak, close to the cardinal line. Possibly a corresponding scar occurs also between the beak and the posterior adductor. This arrangement is, therefore, very much as I have observed it in *Leda bellistriata*, but of the curved oblique internal ridge in the umbonal region with its attachment (?) scar, no equivalent structure has been observed in the present form. The shell is considerably thickened between the beak and the large posterior adductor, however, causing a deep excavation in internal molds, sharply defining the anterior boundary of the scar. The pallial line appears to be entire, or with a faint deflection in the anterior portion. It has not been clearly seen in that portion.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Nuculopsis gen. nov.

The present genus is based upon *Nucula ventricosa* of Hall and it is distinguished from *Nucula* primarily because, though the beaks point toward the short side of the shell, that side is not posterior but anterior. The determination of this fact rests upon the occurrence of a ligamental groove or area along the hinge margin on the long side of the shell. Though varying in the distinctness with which it is shown, traces of this structure can be observed in nearly all the large number of specimens examined. It is, therefore, a real and persistent character of the species and is hardly open to any other interpretation than that which I have put upon it. The existence of this structure then, which has no homologue in *Nucula*, and its almost definitive importance in determining the long side instead of the short side of the shell as posterior, constitute the most important differences from that genus.

The shape is elliptical rather than triangular and the long side is rather produced for *Nucula* itself. The beaks are conspicuously turned toward the shorter side. The typical species has a distinct, though ill-defined and narrow, constriction near the anterior extremity. The lunule and escutcheon are poorly defined. The surface is generally almost smooth. On the interior, there are the usual large posterior and anterior adductors, in addition to which, between those scars and the beaks, a third and fourth pair of muscular imprints can be seen. The dentition consists of a continuous series of taxodont denticles not

apparently interrupted by a chondrophore. The anterior teeth are few and large, the posterior teeth numerous and diminishing in size toward the beak, where they seem to end abruptly against the large anterior teeth. A chondrophore is almost certainly present, but, unlike the structure of living shells, it seems to be situated within and below the row of cardinal teeth without extending to the beak and forming an interruption to them. This cannot, however, be positively asserted as a fact.

Type species, *Nucula ventricosa* Hall.

Limatula ? fasciculata sp. nov.

Shell of medium size, elongate, slightly oblique. Hinge line short. Anterior and posterior outlines probably nearly straight above but becoming more and more strongly curved below, where they merge with the (probably) regularly rounded ventral outline. The convexity is strong with a high area, so that a section cut longitudinally through the two valves would be wedge shaped. On the anterior side the shell descends steeply and abruptly making a rounded angle with the median portion. The posterior side seems to fall away in a low regular flexure.

The surface is marked by regularly arranged costæ or groups of costæ. Toward the anterior side, the costæ are single with relatively wide interspaces. In the median and posterior regions, the costæ are in groups of three or sometimes two, having their tops about on a level, and, in this case, the dividing striæ are essentially equal in width to the groups of costæ. The anterior side, from the angulation to the margin, is smooth. Very likely, the costæ die out toward the posterior side also.

The area is somewhat imperfectly shown by one of the two specimens obtained. It appears to be high and resupinate, so that the beak overhangs the hinge line and it is also rather concave. It is marked by several strong, broad, transverse furrows, but shows no definite pit for a resilium, though, owing to the projecting state of the beak and the concavity of the area, there seems to be an ill-defined hollow under the beak which is rather longitudinal than transverse to the area.

If Hind's *Paleolima* is a valid genus, the present species would be called *Paleolima fasciculata*, for its characters, so far as observed, are consistent with *Paleolima*, but if that genus is to be divided into subgenera along the same lines as the living *Lima*, this species would probably belong in a group as yet unnamed. For the present, however, I am not recognizing *Paleolima* as distinct from *Lima*, so that the generic designation to be used is probably *Limatula*, which is distinguished by being smooth laterally and by having the valves not gaping. The former character seems to be possessed by the *L. fasciculata*, but the latter can not be determined, as we have only dissociated valves. The only other American species referred to this subgenus is the Guadalupian form *Limatula striaticostata*. By a clerical error *L. striaticostata* was de-

scribed under the genus *Limatulina*, but as the genus was ascribed to Wood instead of de Koninck, the group which I had in mind is apparent. The form is clearly not a *Limatulina* and the proper title is *Limatula striaticostata*. It differs from the species under consideration in being much smaller, more oblique, and in having different surface ornamentation.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Scaphopoda

Dentalium semicostatum sp. nov.

This type is represented by two fragments, which, so far as shown, indicate a straight or gently curved, slowly enlarging conical shell. The cross section is distinctly elliptical, having in the larger fragment a diameter of 7 mm. in one direction and 6 mm. in the other. The test is thick and marked by rather fine, rounded, wavy, longitudinal costæ, separated by linear striæ. These markings are confined to one side of the shell, and about four or five occur in 1 mm. There are also transverse constrictions and incremental lines which have an oblique direction to the axis. The obliquity of these markings is in the direction of the long axis of the section, so that their most distal points occur down one of the narrow sides of the shell, and the most proximal down the other. The costæ also are confined to one of the narrow sides, and they occur on that on which the transverse striæ are farthest from the apex.

This shell is somewhat similar to *D. mexicanum*. It has, however, slightly finer costæ at a considerably larger size, and these are restricted to one side of the shell.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Dentalium indianum sp. nov.

Shell rather small, gradually tapering, very slightly curved. Section circular or obscurely elliptical. Surface marked by numerous thin, sharply elevated, longitudinal costæ which are separated by intervals of about double their own width. The number of costæ can not be counted with accuracy, but it is not far from 42. There appear to be also fine, transverse, crenulating striæ.

This form stands nearest to *D. mexicanum* by reason of its numerous fine costæ. These are, however, more numerous and are separated by relatively wider intervals, while the shell itself is gently curved instead of being straight, as in the western form.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Gastropoda

Orestes subgen. nov.

This name is introduced for a group of pleurotomarioid shells which have a shape generally conical or slightly turreted with a gently convex basal portion. The band is not very strikingly defined and has a peripheral position distinctly below the middle of the whorl. The upper surface is in general flattened and oblique, with the zone which lies just below the suture more or less prominent and marked by nodes. The sculpture consists of fine, decussating, revolving and transverse liræ. The slit band is relatively broad and carries one or more revolving liræ which are sometimes nodulose and occasionally conceal to a greater or less degree the structural character of this part of the shell. The slit has not been observed in any of the specimens seen, but it was probably short. The umbilicus was apparently closed, but a reflexed portion of the lower part of the outer lip produces a small excavation which resembles a minute umbilical opening.

The inner lip is without a callosity. In fact, the mantle seems to have had the power to resorb the shell on the inner side of the aperture, so that this portion of the preceding volution is smooth and slightly depressed below the external ornamented areas. This has been observed in many specimens and is surely not an accidental character.

In one extreme, these shells suggest *Euconospira*, from which they differ in their less regular, conical shape, and in the development of nodes below the suture and of revolving liræ in the slit band. They suggest also *Phanerotrema*, but have a more conical shape with a slit band at once broader, less defined, marked by distinctive sculpture and situated not near the middle of the peritreme, but well below. *Worthenia* is in some respects the most nearly related group, at least in the ornamented character of the slit band. *Worthenia* has the band above the middle rather than below, narrow instead of broad, and with the lunules in the band much more prominent than the revolving liræ (in *Orestes* the lunules are hardly more than lamellose growth lines), and it has a more turreted, less conical shape to the whole. It is doubtful if any of the groups mentioned have the peculiar eroded or resorbed character of the inner side of the aperture.

Orestes, then, is referred to a subgeneric position under *Worthenia*, although its relationship to *Phanerotrema* is also obvious. The generic name is introduced in honor of Orestes St. John, one of the early paleontologists of the United States and one of the early geological explorers of Oklahoma.

Type species, *Orestes nodosus*.

Orestes nodosus sp. nov.

Shell small, irregularly conical. Diameter of last whorl about equal to the greatest height, sometimes less. Height of last volution about equal to the height of the spire above. Volutions angular, most prominent below the middle. Spire somewhat turreted. Umbilicus apparently closed, but with the lower lip folded backward upon itself so as to produce a small pit or false umbilicus. Suture considerably depressed. The shell projects strongly from the suture, then bends downward and is flat or concave below to the first carina. Thus the upper third of the upper surface forms a sort of spiral ridge just below the suture. The lateral surface is about one third as broad as the upper surface. It consists of two rather thick, rounded carinæ guarding between them a relatively broad concave channel in which the band is situated. The upper carina is better defined than the other, but does not project quite as far. The lower surface is nearly horizontal, gently convex, more tumid near the umbilicus. The swollen band below the suture is marked by a row of distantly arranged nodes which appear to be independent of the superficial sculpture.

The surface is crossed by regular and nearly equal revolving and transverse liræ of which the former are heavier and dominant, while the latter are more closely arranged. The upper surface carries about five (four to six) revolving lines, arranged at regular and distant intervals. The upper one is situated on the subsutural prominence. An additional lira is occasionally developed just above the latter, which gives the nodes a somewhat elongated double-topped appearance. The upper of the two carinæ bounding the slit is a similar revolving lira of somewhat larger size and so is the lower one. Just within these two liræ are two small edges which define the true limits of the slit band. The band is medially traversed by another fine, revolving thread, or rarely by three. The lower carina carries about two fairly heavy liræ, while the lower surface is crossed by about twelve others, some of which may be fine, and alternating with those of larger size. They are heavier and more crowded than the liræ above. The transverse liræ, doubtless following the outline of the aperture, bend strongly backward, being convex near the suture and straightened or gently concave near the band. Over the latter, they are deeply concave, producing fine, regular, closely arranged crenulations or lunules. On the under side, they run obliquely backward with a strong convex turn on the lower carina. For most of the distance, they are thus nearly straight. In the region of the suture, they seem to be fine, irregular and crowded, passing just below the nodose zone into regular, rather distant liræ which give a finely nodose appearance to the upper carina and generally tend to produce little prominences where they cross the revolving liræ. Even below the nodose zone, fine, intermediate, incremental lines are more or less conspicuous. The transverse liræ do not produce crenulations on the projecting edges of the band, but they have this effect to a greater or less extent on the revolving line or lines which traverse it.

The volutions embrace up to the edge of the band of the preceding one. They are about five in number.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Bellerophon crassus var. wewokanus var. nov.

The fossils under consideration are all of small size. They can be described most advantageously by comparing them with *Bellerophon crassus*, to which they are clearly very closely related. For this purpose, it will be best to use the figures and description given by Meek and Worthen, not only because they are the authentic ones, but because although *B. crassus* has appeared in the literature not infrequently, the citations have seldom been based on the observation of good and characteristic specimens. The most essential difference shown by the Wewoka specimens is that the umbilicus instead of being partly open, is so solidly closed that there must have been a continuous imperforate columella. The size is very much smaller; the shape of the aperture more transverse, and the band possibly more elevated.

It may be that these differences are due to stage of growth, but shells which I am referring to *B. crassus* as representing a young condition are quite different. From these the Wewoka fossils differ in the following particulars. The volutions are relatively narrower; the slit band is broader and more prominent; the umbilici are more completely closed; the sculpture, instead of consisting of rather regular, transverse imbrications, is made up of fine, incremental lines which, at irregular intervals, become fasiculate, forming small angular costæ or incipient plications.

I may add that the fissure as shown on one of the Wewoka specimens is rather deep, but I am not sure that this feature may not have been exaggerated by erosion of the projecting band. Furthermore, on the best specimens, the callosity of the inner lip appears to be imperfectly developed.

It is possible that this may prove to be the same as *B. incomptus*, but after comparing my specimens with Gurley's types, which I have had the privilege of examining, thanks to the courtesy of the Walker Museum of Chicago University, I am disposed to think that they are different. The differences appear to me to be those already mentioned as existing between the var. *wewokanus* and young *B. crassus*.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Pharkidonotus subgen. nov.

The very extensive and varied series of shells which in the course of time had been grouped under Montfort's genus *Bellerophon* have of recent years been distributed among a number of genera and subgenera. Waagen has very properly restricted the genus *Bellerophon* to types having a rather narrow, well-developed slit band, moderately deep fissure, a strong callosity on the inner lip, and sculpture consisting only of more or less strong growth lines.[8]

[8] W. Waagen, Geol. Surv. India, Mem., Ser. 13, Salt Range Foss., vol. 1. p. 130. 1887.

Our well-known Pennsylvanian species *B. crassus* and also the Upper Mississippian *B. sublævis* are therefore typical Bellerophons.

We have in our Pennsylvanian faunas a species, or perhaps a series of mutations, which presents well-marked differences from the characters possessed by typical *Bellerophon*, so that a subgeneric separation is justified, if not demanded. The dorsum is elevated into a prominent nodose carina on which traces of a slit band seldom remain. Many specimens therefore appear to lack such a structure altogether and to be related to the Indian *Warthia* and *Mogulia*. Some specimens retain unmistakable traces of a band, however, and there can be little doubt that this structure is a normal feature of this type. That it is obliterated so often is probably due to its prominent position and also perhaps to the tumid condition of the median line of the dorsum.

From *Bellerophon* this type also differs in the development of coarse, heavy, angular, transverse plications, quite distinct from the growth lines, which are not conspicuous, these plications being also in some cases strengthened at two series of points, one on each of the sides, so as to form more or less prominent nodes (connected in some cases by revolving ridges). The linear arrangement of these nodes produces two carinæ additional to the median one which is the locus of the slit band.

Type species, *Bellerophon percarinatus*.

Meekospira peracuta var. choctawensis var. nov.

This fossil is very abundant in the Wewoka formation and shows certain variations, some of which are probably adventitious. It has an acutely conical form with a very elongate spire and a narrow spiral angle. The sides are usually flat with the suture only slightly depressed, but not infrequently the sides of the spire are more undulating and the suture deeper. This is perhaps due to variation in curve of the outer surface of the whorl. In the one case the convexity is more regular; in the other, the upper surface of the volution is flattened and the greatest convexity well below the middle, where it is overlain by the succeeding whorl. The rate of increase seems to be accelerated somewhat toward maturity, so that the sides of the spire are slightly concave. As a result, when the apex of specimens is broken away, which very often happens, the frustum remaining appears to have a wider spiral angle than was really the case. In comparing these with more perfect specimens, one is somewhat surprised to find that they may belong to the typical variety, as well as to find what a large number of volutions is present when the apex is complete, the number being proportionately much greater toward the top. On the side of a specimen 14 mm. long, parts of nine volutions appear and as the apex is broken, there must have been one or two more. A full-sized specimen about 30 mm. long shows parts of ten volutions with an apical break which may possibly account for two more. The number of complete volutions in a mature specimen is probably eleven and possibly twelve.

The callus is a very distinct character in well-preserved specimens, extending half way or a little less than half way up the inner lip. It is formed by a slight backward flexure on itself of the outer lip as it passes up the axis and is there gradually lost in the aperture.

In its specific characters this species is intermediate between *Meekospira peracuta* and *Bulimorpha nitidula*, and it does not exactly agree with either species. According to Meek and Worthen, these types show the following differences: *B. nitidula* has a lower spire with fewer volutions and broader spiral angle; it is smaller, and the volutions are more rounded with more deeply depressed sutures.

The present form seems almost invariably to have a slightly broader spiral angle than *M. peracuta*, though a certain amount of variation is not absent. The agreement in this respect is then distinctly with *B. nitidula*. As for the convexity of the volutions, some specimens resemble *peracuta* and others *nitidula*; but few, perhaps none, are quite as strongly convex as in Meek and Worthen's figures of the latter species. In fact, one of their figures shows this character more strongly than the other, though both are drawn from the same specimen. The number of volutions is more like *peracuta*, which is said to have 13, than *nitidula*, which is said to have 8 or 8.5. The size is that of *nitidula*, none of the specimens attaining to the length of *M. peracuta*. In the most essential respect, the callus and reflexed lip, the Wewoka form agrees with *M. peracuta* and differs from *B. nitidula*, and, if this character is regarded as of generic importance, there can be no question about associating it with any species but *M. peracuta*. Ulrich seems inclined to associate *B. nitidula* and *B. inornata* with *M. peracuta* in his genus *Meekospira*, but the callus, which is such a marked feature of *M. peracuta*, must be a generic character, or its absence from the two other species accidental. This assumption seems unwarranted, and I am referring those two species to another genus than *Meekospira*, in which, of course, the present form must be included. Though closely related to *M. peracuta*, I can hardly place it in the same species, because of its broader spiral angle and smaller size.

Most of the specimens referred to this species are almost absolutely smooth, having but very obscure growth lines. Those from one or two localities, however, are regularly marked by more or less strong incremental lines, some of which are prominent and lend an irregularly and intermittently corrugated appearance where most strongly developed. Some of these shells, furthermore, show slight modifications of curvature in the outer surface of the volution, which gives the spire a slightly different outline from the normal. In others, however, the shape of the whorl section is entirely normal, so that no persistent difference can be pointed out, save in the increased development of the striæ of growth. It is possible that these sculptured specimens should be regarded as a separate variety, but the differences observed hardly seem to justify the distinction.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Ianthinopsis gouldiana sp. nov.

Shell rather large, subovate; length a little less than 1.5 times the greatest width. Aperture about three fourths the entire height; spire about one eighth of the whole. Volutions four or five, rather inflated, especially above, so that the upper surface of the volution appears flattened and not strongly oblique to the horizontal. Aperture fusiform, more than twice as long as wide.

Surface smooth but marked on the more gibbous portion with a few (four or five) rather coarse but faint revolving striæ. Axis solid.

The affinities of this type, represented as it is by only one specimen, are much in doubt. If it were not for the sculpture and for the shape with the most prominent part of the volutions so high up, this shell might be placed under *Sphærodoma* in the same series with *S. intercalaris* and *S. primigenia.* The striation, though faint, is unmistakably visible in a good light, but it can only be seen in the region of the aperture. The shape has doubtless been somewhat modified by compression, but not sufficiently to have produced the present result from a shell originally having the proportions of either of the species named.

On the assumption that the peculiarities presented by this form are inherent, it may be compared with the singular species described by Meek and Worthen under the name *Pleurotomaria ? tumida.* While clearly distinct from *P. ? tumida,* the resemblance in a general way is so striking that it would appear to be ultraconservative not to conclude that it is a generically related species. The most important difference of a fundamental kind is found in the statement by Meek that the columella of the Illinois form is perforated (?), while that of the Wewoka shell is certainly solid.

Meek had not observed the presence of a slit band in *P.* (?) *tumida,* and justly remarked that that species differs materially in outline from the usual form of *Pleurotomaria.* Suspecting that it was a representative of a new genus, he provisionally proposed the name *Ianthinopsis.* I am ready, without having determined the absence of a slit band, to accept *I. tumida* as representing a new generic type, and I am employing *Ianthinopsis* for the type specimen and for the Oklahoma shell also.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Cephalopoda

Orthoceras tuba sp. nov.

Orthoceratoid shells are abundant in the Wewoka formation and many of them possess the singular feature of accelerated expansion, so that they flare conspicuously at the larger end, and, if the tendency were carried out to a high degree, the complete shell would have a trumpet-shape, a configuration which many of them even now suggest. This peculiarity, however, is manifested in shells of very various sizes and presumably corresponding ages, and it is found in both the chamber of habitation and in the septate portion. Both hypotheses—that the flaring condition is a feature of maturity (which is the natural supposition) and that it is the normal shape at all stages, the expanded portion being resorbed so that the shell is regularly conical except toward the aperture—are repugnant to the fact that the flaring portion is sometimes septate. On the former hypothesis, furthermore, we must also infer that the mature condition is in some specimens enormously accelerated or retarded.

Correlated with the peculiarity above described is found a relatively rapid rate of expansion, giving the regular portion of the cone a rather strong taper. The siphuncle is conspicuously excentric, though this character has been seen in only a few individuals which at the same time have the trumpet-shape in a conspicuous degree. The septation is rather frequent, about 4.5 to 5 chambers occurring within the distance of a diameter.

None of the shells having the characters enumerated possesses the peculiar secondary deposits of *Pseudorthoceras*. Indeed, they have the chambers filled with ochreous clay, and it is difficult to understand how this condition came about when the partitions are still retained. Possibly the fine mud permeated the chambers through the siphuncle, which seems seldom to be preserved in the specimens examined. For the most part, these are internal molds, but in some instances they retain a substantial outer investment.

With typical *O. tuba* I am provisionally including a group of specimens which do not show the expanded aperture, but have a similarly excentric siphuncle and similarly frequent partitions. They vary much in size and some of them are much larger than some of those which show the accelerated expansion, but in view of the extreme variation in size of the specimens possessing the latter character, it seems that this fact alone can hardly be regarded as forbidding their union under a single species. This, of course, would only be done on the hypothesis, either that the trumpet shape was not a character of importance, or that these specimens, all of which are naturally now imperfect, possessed it or would have possessed it in the complete and mature condition.

I am inclined to believe that this peculiarity of configuration is not so much a specific character as that it is either generic or else of no fixed value at all, but I feel that its significance is too little understood to warrant establishing a new genus on the evidence in hand.

It is with extreme rarity that shells of this group are found in a complete condition, and all of those examined are pretty clearly imperfect at one or both ends. A few give evidence of having been broken before fossilization. The evidence referred to consists of the occurrence of small Rœmerellas apparently in their original position of attachment upon the septa, where, of course, they could not possibly have penetrated if the shell had not been a fragment during the life of the brachiopod.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Pseudorthoceras gen. nov.

Shells small (?), straight, gradually tapering. Siphuncle nearly central, small, but considerably expanded between the septa, without, however, becoming nummuloidal. Septa simple. Funnels apparently very short and thick. Chambers partly occupied by secondary deposits which accumulated, not about the funnels and siphuncle, but about the walls. In the type species, the deposits fill about half of each chamber, thinnest toward the aperture and thickest toward the apex, and diminishing irregularly so that the outline is shaped like an incomplete letter S. The deposit appears to be more or less vesicular, perhaps as the result of weathering. Shells which are not broken at the apex do not taper to a point, but are obliquely truncated.

This type is rather clearly not a representative of true *Orthoceras*, nor have I been able to find a genus with which it can be assembled. Indeed, it is not certain that it can be included among the Orthoceratidæ, though it is for the present referred to that family. The most diagnostic features are probably the enlarged siphuncle and more especially the secondary deposits accumulated not axially, but circumferentially. In this item lies the main difference from *Orthoceras*, for in that genus, and indeed in that family, the secondary deposits are rather sparingly developed and they are accumulated about the funnels, not about the outer wall.

Type species, *Pseudorthoceras knoxense* McChesney.

Pseudorthoceras seminolense sp. nov.

Three specimens in the collection appear to belong to *Pseudorthoceras* by reason of their central siphuncle and chambers partly filled by secondary deposits and at the same time to differ from *P. knoxense* in being very much larger. These large specimens have about 3.5 chambers to a diameter and so do not differ essentially from the smaller species. One of the specimens is

compressed and seems to show a structure down one side suggesting a marginal siphuncle.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Protocycloceras ? rushense var. crebricinctum var. nov.

Two specimens, though resembling *P. ? rushense*, are distinguished by having the annulations more closely arranged and somewhat alternating. The cross-section is elliptical as in that species, but there is an acceleration of expansion which produces a flaring shape toward the aperture. The recurrence of this latter character, which is found to a marked degree in one of the species of *Orthoceras*, is noteworthy and seems to bring its importance somewhat into doubt. Its significance is entirely unknown.

One of the specimens shows the surface to be marked by fine, subequal, somewhat wavy, thread-like, transverse liræ.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Coloceras liratum sp. nov.

Shell small, the largest specimen seen measuring 34 mm. in the plane of revolution. Shape subglobose. Cross-section sublunate, somewhat gibbous at the sides. Surface rather regularly curved over the venter and sides, abruptly rounded inward at the umbilicus, forming two not very well-defined umbilical zones, the direction of which is nearly horizontal. At maturity, the section is about twice as wide as high. In mature specimens, the median line of the venter is broadly and faintly impressed. The rate of increase is rapid and the depressed zone narrow, considerably less than one half the width of the preceding whorl. The umbilicus is rather small and deep.

The surface is marked at the sides by fine revolving liræ, separated by wide, flat interspaces. These extend from the umbilical zone over the subangular shoulder onto the extreme sides of the venter. The revolving liræ are crossed in some cases by much more closely arranged transverse ones which make fine crenulations as they surmount them. The entire surface of the immature stages seems to be thus cancellated, but only a band on the sides of the mature shell, while on the oldest specimens and some others, the transverse markings cannot be seen. The ventral surface is crossed by fine, incremental striæ, which indicate a deep, subangular V-shaped sinus, whose sides are nearly straight over the median portion but curve gracefully outward with increasing rapidity toward the sides. In one specimen, the striæ are so arranged that every seventh or eighth is stronger than the others, which cross the slightly elevated spaces between in crowded though regular order.

The septa are rather far apart, about 6 mm. along the median line in a mature specimen. They are nearly straight except for a slight sinuosity across the venter caused by the shallow ventral lobe and a pair of obscure saddles. The siphuncle appears to be situated below the center (dorsad) but it is not well shown.

This species is related to *C. globulare.* It appears to be a more slender form (though specimens vary somewhat in this), with more distant septa which show a slight lobe instead of a slight saddle on the ventral surface. The sculpture of *C. globulare* is not known, so that additional differences may be discovered when those data are determined for it.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Coloceras liratum var. obsoletum var. nov.

Associated in most cases with *C. liratum* are specimens which show certain differences, the most constant of which is perhaps the absence of liræ on the umbilical zone. Correlated with this character the curvature at the sides is more regular, so that the umbilical zones themselves are less well defined. The incremental markings are perhaps stronger, or at least more regularly preserved. Some of the specimens are rather narrow but not all. At the same time, since the sculpture on typical *liratum* might easily be obscured, it is possible that some specimens of the latter may be included here. The siphuncle of this species seems to be ventrad or at least central, while that of *liratum* is or appears to be dorsad, but this feature is rarely shown and in the case of *liratum* not well shown by my specimens.

There seems to be a varietal or even a specific difference here, but my material is not sufficiently good to show the degree of difference or the constancy of it from *C. liratum*, or whether possibly the shells subsumed under this title are in every case conspecific.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Metacoceras cornutum sp. nov.

This species is founded on a fragment which must have had a diameter of 70 mm. exclusive of the chamber of habitation, no portion of which is retained. The whorl section is subquadrate, distinctly wider than high. The height is 23 mm. and the width 29 mm. The ventral surface is gently convex, more nearly flat on the shell itself than on the internal mold. The sides, exclusive of the prominent tubercles, are nearly flat and parallel. The lower portion of the whorl is tripartite, consisting of an impressed zone about 12 mm. wide and two umbilical zones, each about 8 mm. wide. The umbilical shoulder is abrupt and angular, the angle being somewhat greater than a right angle. The ventrolateral shoulder is also angular and furnished with large, prominent, compressed nodes. They project outward and slightly upward and are flattened on the upper surface, more convex on the lower. Those on one side alternate with those on the other and in the same row they occur on about every other chamber.

The septa are about 6.5 mm. apart, measured along the median line of the venter, and the sutures are rather strongly bent. There is a broad, deep

ventral lobe almost angular at the middle in some sutures, a broad, moderately deep lateral lobe, the point of greatest convexity being below or interior to the middle, and a gently curved internal or dorsal lobe across the impressed zone. Abruptly rounded saddles occupy the ventrolateral angles and a broad saddle flattened across the middle, each of the umbilical zones. Each of the latter, however, may be regarded as composed of two obscure saddles, one on the umbilical shoulder and one on the angle of the impressed zone with a scarcely perceptible lobe between.

The sculpture is not well shown. On the ventrolateral angles and tubercles it consists of regular, strong, sharp, transverse liræ, which are deeply curved, suggesting a broad, deep hyponomic sinus.

The test appears to be considerably thickened at the ventrolateral angles so that the internal mold differs appreciably from the perfect shell, the shell being flatter across the ventral surface, with the sides more convergent toward the umbilicus, and with the tubercles very much more produced. Indeed, on the internal mold, the tubercles are not at all prominent.

Horizon and locality: Wewoka formation; Coalgate quadrangle, Wewoka quadrangle, Okla.

Metacoceras cornutum var. **sinuosum** var. nov.

A single fragmentary specimen which retains the shell is all that represents this variety. It is smaller than the original species and with a less transverse cross-section. The nodes are rounded instead of compressed and extend part way down the sides as low, broad, obscure plications which fall far short of the umbilical shoulder. The latter is regularly rounded and although strongly turned, not angulated. The ventral surface is marked by two obscure sulci with a gentle convexity between. The tubercles appear to be nearly opposite

The surface is almost smooth, the incremental lines being obscure except on the tubercles, where they develop into regular, fine, though sharp liræ. They make a deep sinus on the ventral surface, are nearly straight and gently sloped backward at the sides, with a gradual change of the direction at the umbilical shoulder, beyond which on the umbilical zone they are gently concave

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Metacoceras cornutum var. **carinatum** var. nov.

This variety is represented by two fragments which apparently show the chamber of habitation, but do not retain the septa. They are partly testiferous and partly exfoliated.

The variety *carinatum* is distinguished from either of the preceding by its more rapid expansion and more transverse shape, in which it exceeds even the original species itself. The sides are in consequence relatively very narrow. The tubercles are rounded as in the variety *sinuosum*, but owing to the shortness of the sides they make more prominent plications. The ventral surface is rather strongly rounded and without sulci. The umbilical shoulder is very angular and extended into a crest or carina,—in which a marked difference is

shown from the variety *sinuosum*, though possibly not from *M. cornutum* itself. The growth lines indicate the presence of a deep hyponomic sinus.

It may be that these shells represent a young stage of *cornutum* (though hardly of the variety *sinuosum*), but they present too important differences (the rapid expansion, greater breadth and differently shaped tubercles) to make it safe to assume this relationship without more evidence.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Metacoceras cornutum var. **multituberculatum** var. nov.

This variety is founded on a crushed specimen which presents the difference from all the others that the tubercles are smaller and more closely arranged. They appear to be somewhat compressed rather than rounded. The umbilical shoulder is subangular without the crest of *carinatum*, but more rounded than *sinuosum*. The height between the ventrolateral and umbilical angles is about 10 mm.; the width across the venter (tubercles included), about 15 mm.

Horizon and locality: Wewoka formation; Coalgate quadrangle, Okla.

Metacoceras perelegans sp. nov.

Shell rather small, so far as known not exceeding 31 mm. in diameter. Cross-section of mature whorls hexagonal, transverse; width about 20 mm.; height about 12 mm.; width of lateral zone 7 mm.; of umbilical zone 6 mm.; of impressed zone 8 mm.; of ventral zone, including tubercles, 17 mm. Ventral surface gently convex, flattened or slightly depressed along the center, gently upturned at the edges, owing to the tubercles. Lateral zone nearly flat except for the tubercles, the projection of which gives it a gently concave shape. Umbilical zone nearly flat. The lateral zone slopes gently outward from above and the umbilical zone strongly inward. In the youthful stages, the dimensions are increasingly transverse and the shape more nearly elliptical, with an angular periphery a little above the middle and with the usual recurved dorsal zone. This change in shape is effected (when considered in reverse order) by an increased inward slope of the umbilical zone and a corresponding loss of the umbilical shoulder. Both the ventrolateral and the umbilical shoulders, however, are more or less distinguished by an angulation.

The sculpture of the youthful stages is incompletely known, but the sides of the youngest example seen are marked by fine, even, transverse, rounded striæ, separated by narrow, sharp liræ. Later, the flattened sides are marked by strong, regular plications, the folds being angular and the furrows between relatively broad and rounded. On these are superposed strong, incremental striæ, much less distinct in the furrows than on the crests between them. The pilæ thus gradually formed tend to become more prominent at the ends, developing little nodes in which they terminate, the nodes appearing at an early stage and more strongly at the outer than the inner ends. At maturity the connecting ridges gradually fail of development, leaving the two rows of

nodes, the larger and more prominent along the ventrolateral shoulder, the smaller and less prominent on the umbilical shoulder. Both these loci are well defined and more or less strongly angular during the periods of adolescence and maturity.

The sculpture at maturity consists of very obscure incremental lines which tend to become sharp liræ on the tubercles, and they show a deep sinus over the ventral surface.

The septa are not well exhibited by my specimens, though this is a fairly common fossil in the Wewoka fauna. In a mature example, they are 3.5 mm. apart along the middle of the venter, and the suture is very nearly straight, depressed, however, into a shallow ventral lobe and with very obscure saddles on the ventrolateral shoulders. In this region, the suture is liable to be more or less deflected by the pilæ, which are not developed exactly with regard to the septa. In some cases the nodes occur on the septa; in others between them, and there are about three nodes to four septa. In a young specimen which probably belongs to this species, there is a suggestion of a very small, pointed dorsal lobe, somewhat as in the genus *Endolobus*. The siphuncle appears to be central or somewhat below the center.

I know of no American nautiloid which this species so much resembles as that which Hyatt described as *Temnocheilus crassum*. The whorl section of *perelegans* is more transverse and somewhat differently shaped, with distinct umbilical shoulders. The pilæ have nodes at both ends instead of near the ventral surface only, and at maturity they disappear, leaving only the two rows of nodes.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Metacoceras sculptile sp. nov.

Shell rather large, attaining a diameter of 67 mm., discoidal, with large umbilici, 31 mm. across at the diameter named.

Whorl section modified hexagonal, consisting of a relatively narrow ventral surface, two broad lateral surfaces, two umbilical zones and an impressed zone, all narrow. The ventrolateral and umbilical angles are distinct and only slightly rounded. The ventral surface is marked by two shallow sulci situated close to the margins, on either side of which the shell rises slightly into a gently convex median portion and gently elevated ventrolateral angles. The sides are flattened and slope distinctly outward from above to the umbilical shoulder. There, with an abrupt subangular change of direction, they are withdrawn inward and somewhat downward to a rather deeply concave impressed zone. Greatest height of the final volution 31 mm.; greatest width (at the umbilical shoulder) 25 mm.; width of ventral surface 15 mm.; width of lateral surface 24 mm.; width of umbilical zone 8.5 mm.; width of impressed zone 9.5 mm.

The sculpture seems to consist of fine, even striæ, which follow the lines of growth, leaving between them sharp, strong, angular liræ. This sculpture, however, is more or less concealed in our specimens by a thin, even, super-

ficial deposit, whether intrinsic or extrinsic I am unable to determine. This makes the surface look either smooth or, as the sculpture shows through, marked by obscure lines of increase. The liræ, which seem to strengthen and coarsen as they cross the ventrolateral shoulders, form a deep sinus on the venter. On the sides the direction is sigmoidal, convex above and concave below; similarly on the umbilical zone, save that the concave portion, which is below, is very slightly developed. When mature, the ventrolateral shoulders are marked by small, rather indistinct nodes.

Suture not known.

This species is of the type of *M. walcotti* and *M. hayi*. From both species it seems to differ in having the height proportionately less in comparison with the width; in having the sides contract toward the venter; in having the umbilical zones more nearly horizontal and the umbilical shoulders perhaps a little more angular. The nodes along the ventrolateral angles appear to be smaller and less distinct than in *M. hayi*, while the sculptured surface of *M. sculptile* is not recorded for either species.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Cyrtoceras peculiare sp. nov.

Shell rather small, expanding with extreme rapidity. Apical angle about 60°. Axis nearly, if not quite, straight. The rate of expansion is so great that unless the shell grew to a very large size, the curvature of the axis would hardly be preceptible. The sides, therefore, appear to be nearly straight, but that on which the expansion is least rapid may probably be regarded as the dorsal and the other as the ventral side. The siphuncle then is strongly dorsad. The cross-section would be broadly oval, contracting toward the dorsal side, which is somewhat flattened. Only five chambers are preserved, the oldest being about three times as high as the others. The prolongation of the chambers is so rapid on the ventral side that in the internal mold they make step-like projections. The sutures are nearly direct, but are more or less distinctly sinuated, with gentle lobes on the dorsal, ventral and lateral surfaces, and equally faint saddles between.

The extremely rapid expansion of this species distinguishes it from the few Carboniferous representatives of the genus known in North America. It is, however, very doubtful whether this is a true representative of *Cyrtoceras*, a question which can be raised with equal propriety regarding the other American Carboniferous species referred to the genus.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Gastrioceras venatum sp. nov.

Shell small, attaining a diameter of 18 mm., compressed globose. Umbilici rather large and open. Whorl section lunate, somewhat tumid at the sides with an ill-defined umbilical shoulder.

Sculpture consisting of angular pilæ or plications at the sides with relatively broad, rounded interspaces. The pilæ are short and divide irregularly into three or four branches of inferior size and prominence. Similar small plications are developed simultaneously in the sulci between the pilæ, all of which become crowded and finer, so that the venter is crossed by regularly arranged, moderately coarse and strong striæ which form a rather broad, deep sinus as they cross to the other side.

The suture is rather simple. The siphonal saddle is small and indented on top. The remaining lobes and saddles are rounded. The first lateral saddle is rather broad and symmetrical; the second, still broader and very unsymmetrical, the outer side being straighter and more extended than the inner. The two lobes are symmetrical. The first is very small, narrower than the siphonal saddle. The second is fully twice as large as the first and somewhat more spreading.

This species resembles the few Gastriocerata described from the Carboniferous of America which have plicated sides, but the plications in this case are finer and branching in a rather unusual manner. The suture is also distinctive in that the lobes are rounded instead of angular. In some respects the characters shown by this species suggest that it is an immature stage, but some fifteen specimens have been examined, all of which are of small and more or less uniform size.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Gastrioceras hyattianum sp. nov.

Shell subspherical with relatively wide umbilici when young; compressed globose with relatively narrow umbilici when mature; attaining a rather large size, the largest example having a diameter in the plane of revolution of 65 mm. and being about 37 mm. thick at the widest part of the final volution. Umbilical shoulder angular and more or less carinated at all stages, except perhaps when very immature. Cross-section broadly lunate in the young and narrowly lunate in the mature condition. In the latter, the curve of the venter and sides (which are not differentiated) is parabolic, gradually expanding toward the umbilicus and much more strongly curved above than at the sides. In this condition the whorls are deeply embracing. Specimens of nearly the same size seem to vary considerably in thickness, some being more discoidal, others more globose. The chamber of habitation is long, one volution or possibly more.

The surface when very young is probably cancellated with fine transverse liræ and fine revolving ones. In an early mature condition, the strength of the liration seems to have diminished considerably. The transverse liræ are finer but persistent, while the revolving liræ become restricted to the umbilical surface and the sides of the ventrolateral surface, the major portion of the venter showing only transverse markings. These have a more or less sinuous course with a gentle saddle in the center and obscure lobes toward the sides.

When mature, the shell seems to have been perfectly smooth, without liræ of either sort, except possibly a few revolving ones on the umbilical shoulder. My specimens do not show this sculpture, except here and there, and the foregoing statements are based on scattered observations and not on any one specimen, still less on a series of specimens showing consecutive changes.

The suture (observed on a shell in an early mature stage) shows a high, narrow ventral saddle, indented on top, and two rounded lateral saddles, the first of which is relatively narrow and symmetrical and the other broad and unsymmetrical. Both are considerably higher than the ventral saddle. The two lobes are tongue-shaped, the inner one being narrow and the outer broad and unsymmetrical. A third, broad, tongue-shaped lobe, smaller than the others, is found on the umbilical zone.

This species closely resembles *Gastrioceras occidentale*, the only positive difference of any moment suggested by the description and figures being that the umbilical shoulder of the latter is obscurely crenulated or subnodose. As neither the suture nor the sculpture are known, however, adequate grounds for comparison are wanting.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Gastrioceras angulatum sp. nov.

Shell of medium size, subglobose. The largest specimen has a diameter of 32 mm. Cross-section trapezoidal, much wider than high. Umbilical shoulders very angular. Umbilicus wide and deep. Ventral surface broadly rounded, more or less parallel to the impressed zone. Constrictions about five to a volution, gently curved across the venter with the convex side forward. A typical specimen has a diameter of 30 mm. with an umbilicus 16 mm. wide. The thickness at the widest part of the final volution is 25 mm. The height of the final volution is 7 mm., the width of the impressed zone 17.5 mm. A small specimen having a diameter of 15 mm. is composed of seven volutions.

The surface over the venter appears to be smooth when the shell is mature. The region of the umbilical shoulder, however, is marked by moderately coarse, revolving liræ, crossed by about equally coarse transverse liræ. This cancellated area appears to be narrow and to extend to or just beyond the umbilical shoulder, leaving the umbilical zone smooth. Doubtless in the younger stages, the whole surface was cancellated, though this fact is not shown by my specimens. In the later stages also, the transverse cancellating liræ appear to be absent, leaving only a few revolving ones on the umbilical shoulder.

The suture is not well shown by my specimens. There is a narrow, bifid siphonal saddle with sigmoidal sides. The first lobe is extraordinarily narrow, not so wide as the siphonal saddle and less than half as wide as the second lobe. Both the lobes are tongue shaped. The saddles are rounded, the first a little broader than the second, and they are considerably higher than the siphonal saddle. The umbilical shoulder passes through the outer side of the second saddle and doubtless a third tongue-shaped lobe is situated on the

umbilical zone. The internal sutures consist of three tongue-shaped lobes of very nearly equal size and shape, two rounded saddles, also nearly equal, and half of two others, one at either margin, each being interrupted by the limit of the depressed zone.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Dimorphoceras lenticulare sp. nov.

This species is known only from one or two fragments but the characters shown are sufficient for a fairly complete description.

The shape is discoidal, much thicker at the umbilicus than at the venter. The size indicated is about 40 mm. in diameter and about 13 mm. in thickness. As only the septate portion is known, complete specimens must have been considerably larger. The umbilicus was small and the shell highly involute. The shape of the whorl section is somewhat triangular, slightly higher than broad. The sides are gently convex, strongly and regularly contracting to the ventral surface, which is narrow and sharply rounded. Probably, there was a more or less distinct umbilical shoulder and a narrow umbilical zone.

There is a broad, rounded ventral saddle with a median notch. The lateral sutures consist of two parts, that toward the umbilicus having large turns and that toward the venter having small ones. The small folds, which comprise two lobes and a saddle, can be thought of as a large lobe coördinate with those toward the umbilicus, which has been divided by a median saddle. The three plications thus formed are nearly equal, but the first lobe and the saddle are rounded, while the second lobe is tongue-shaped. The saddle is a little narrower than the two lobes, and the second lobe projects a little farther backward than the first. The remainder of the suture consists of high angular plications, a saddle and a lobe, together with the major part of another saddle, all of which probably comes within the limits of the visible suture when fully exposed. These lobes and saddles are asymmetrical and have more or less sigmoidal sides. They are so arranged that the point of the lateral lobe is almost in contact with the outer side of the preceding lobe somewhat less than half-way up. The final saddle is broad, rounded and asymmetrical.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Dimorphoceras oklahomæ sp. nov.

Shell lenticular in shape, thick in the middle, thin at the edges. Diameter 50 mm., thickness 20 mm. Highly involute with small umbilici (about 5 mm.). The whorl section is more or less triangular, with gently convex, converging sides, and narrow, strongly rounded venter. Umbilical shoulder distinct; umbilical zone narrow.

Ventral saddle rather narrow, indented on top. The two small ventral lobes are pointed and tongue shaped, the first one short, the second long and narrow. The saddle between them is rounded. There is not much difference between

these four lobes and saddles in the matter of width. If anything, the ventral saddle and the small lateral saddle are a little wider than the two lobes. The large lateral saddle and lobe are about equal, moderately narrow, with somewhat sigmoidal sides. The suture seems to form part of another large, rounded asymmetrical saddle. Only part of the outer limb of this is retained on the only specimen found, but probably the remainder appeared on the confines of the visible suture not exposed in the type.

This species is most closely related to *D. lenticulare*, from which it has been discriminated because of the suture. The differences manifested in this feature can hardly be ascribed to difference in age, because the two type specimens must have been nearly of a size and presumably at a corresponding stage of development. The differences noted are the narrower ventral saddle, the pointed instead of rounded shape of the first small lobe, and the much elongated shape of the second. The outer sides of the first large lobe are also more approximate. *D. oklahomæ* differs from *D. texanum* in about the same characters as those pointed out for *D. lenticulare*, but is rather more closely related. This is shown, for instance, in the first small lobe, which is pointed in *oklahomæ* and *texanum*, but rounded in *lenticulare*.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

Gonioloboceras welleri var. **gracile** var. nov.

This species attains a diameter of 53 mm. in a fragment entirely septate. The type specimen, however, has a diameter of 43 mm., with a thickness through the center of 14 mm. The umbilici are small, only 3 mm. wide, and the whorls highly involute. The sides are gently convex, contracting to a very narrow venter marked by a revolving channel guarded by two thin, angular ridges. In the early stages the shell is less compressed and the venter less distinctly channeled. When still younger, the venter was probably rounded, but the two carinæ with their inclosed groove are largely a development of the test and do not show clearly on the internal mold. The surface appears to be marked by obscure, incremental liræ, the direction of which indicates a deep, broad, hyponomic sinus.

The suture consists of two lobes and two saddles on each side, together with a high, broad, siphonal saddle. This is rounded, but with a notch (?) on the median line. The latter feature is not clear. The suture lines bend sharply backward near the middle, but in most specimens they appear to be disconnected. In one, however, they appear to connect into a small V-shaped reentrant angle. The second saddle is broad and unsymmetrical. The first saddle and the two adjacent lobes are very nearly equal, the second lobe being slightly broader. They are subangular, but not acutely pointed. The sutures are closely arranged, the inner sides of the first saddles being almost in contact.

This form is closely related to *G. welleri*, but differs in some particulars. J. P. Smith figures two mature examples of *G. welleri*, and it is perhaps desirable to distinguish between the type and the auxiliary specimen. The type specimen of the variety *gracile* is a little more compressed than the specimens of *G. welleri*, but I am not sure that the difference would be constant. The venter also seems to be narrower and to show the channeled condition at a stage when the type of *G. welleri* was rounded. The sutures are more closely arranged than in Smith's second specimen, but not more so than in his type. This feature is better shown in the former, from which the detail was drawn, than in the latter. The sides of the lobes and saddles are more sigmoidal as given by Smith. They are very nearly a constant distance apart, whereas in the Wewoka form, they are almost in contact at one point as described above, and the first lobe is much narrower. These differences are not so marked in the case of the type specimen, but there the point of the second lobe is nearly in contact with the inner side of the lobe immediately preceding, an arrangment quite different from the variety *gracile*. Furthermore, Smith definitely states that the ventral saddle in his form is not notched, but has a tongue-shaped forward extension, whereas the extension in my shell is as certainly backward.

These differences appear to be rather constant for the material examined, and it seems unwarranted to consider the Wewoka form as quite identical with the other.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Coalgate quadrangle, Okla.

Crustacea

Griffithides parvulus sp. nov.

Carapace small, elliptical, length about 2.5 times the width, nearly equally divided between cephalon, thorax and pygidium. The head, however, even without the genal angles, is longer than the pygidium.

Cephalon semi-elliptical in shape, considerably wider than long (if the width is measured from the anterior extremity to the edge of the neck ring), rather tumid. Genal angles prolonged into spines of undetermined length. A broad, striated border passes around the arc of the cephalic shield, terminating posteriorly in the genal spines. The border is strongly arched or subangular transversely, so that the outer surface is directed obliquely downward and outward, and the inner surface obliquely downward and inward, thus causing it to be defined from the inner parts of the cephalon by a deep sulcus. The sulcus dies down to a depressed line as it passes around the front of the glabella, and at the same time the direction of the border be-

comes so changed that its surface is essentially vertical, and so that the anterior outline of the glabella is terminal, when the head is seen from above. Outline of the facial suture very sinuous. The sutures almost come together at the end of the glabella, diverging strongly as their course is traced backward. At the sulcus which defines the border, they assume an opposite direction, contracting gently for an equal distance. They make a strong arch around the palpebral lobes and from the neck furrow pass somewhat obliquely outward to the articulating margin. Glabella much wider toward the front than behind, occupying nearly the whole of the cranidium, so that there is little of the fixed cheek, except the rather small palpebral lobes. The neck furrow is strong and broad, passing almost directly across the cephalon to the two sulci defining the border. The neck ring is very broad, oblique, prominent. much wider than the sort of band with which it is continuous, which is produced on either side by the neck furrow. The posterior part of the glabella is subdivided into three knob-like lobes by two oblique furrows cutting off the corners, so to speak, and a cross furrow connecting these parallel to, and a little in front of, the neck furrow. These lobes are rounded, and the furrows between coalesce around them into an undefined depressed area. A partial and indistinct transverse furrow, a little in front, indicates a second annulation of the glabella. The glabella is tumid, the palpebral lobes and neck ring very prominent. The large, elliptical, many-faceted eye is strongly oblique and the free cheek just external to the eye also slopes strongly downward toward the border. A small subangular ridge passes around the outer margin of the eye.

The somatic segments are 9 in number, with a highly arched axial lobe which comprises about one third of the entire width. The pleural lobes are much depressed and defined from the axial portion by sharp sulci. They are nearly planate over the median portion, but bend strongly and abruptly downward about half way to the extremity. The pleural portion of each segment is subdivided by a furrow which reaches almost to the axis.

The pygidium is semi-elliptical in outline, broadly rounded posteriorly and with a broad, smooth, oblique and depressed border which narrows somewhat anteriorly. The axis is strongly and sharply elevated and defined by well-marked grooves. It is flattened on top and nearly quadrate in section. The lateral lobes are moderately inflated, the convexity being irregular, so as to produce an angulation down the center of each, appearing on the segments on either side as a row of prominences or nodes. The segmentation of the pygidium is strong, produced by deep, sharp grooves which do not extend onto the border nor onto the sides of the pygidium. They produce about 12 axial rings and about 7 lateral ones.

The surface is marked by granules or small nodes which appear on the more prominent parts of the surface, on the basal portion of the glabella, on the crest of the neck ring, along the little ridge under the eyes, and in rows across the segments of the axis of both thorax and pygidium. The pleural segments are either without these nodes or have them fewer, smaller and less conspicuous.

If we except *Griffithides sangamonensis*, which I believe to be a *Phillipsia*, only two species of *Griffithides* are known in our American Pennsylvanian, *G. ornatus* and *G. scitulus*, and of these only *G. ornatus* appears to be marked with nodes like the present form. In many respects *G. parvulus* is very similar to *G. ornatus*, but aside from being very much smaller, it presents important and striking differences in the configuration of the basal portion of the glabella.

Horizon and locality: Wewoka formation; Wewoka quadrangle, Okla.

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A LIST OF THE TYPE SPECIES OF THE GENERA AND SUBGENERA OF FORMICIDÆ[1]

BY WILLIAM MORTON WHEELER

(Presented by title before the Academy. 16 October, 1911)

Although at the present time the taxonomy of the Formicidæ is in much less confusion than that of many other families of Hymenoptera, there is nothing to indicate that this fortunate state of affairs will survive the present generation of conservative myrmecologists. And, as it is very generally conceded that confusion in taxonomy often arises from a failure to recognize generic types, it seems advisable to publish a list of these for the Formicidæ. This is the more urgent, because Shuckard, Emery and Bingham are almost the only authors who have expressly designated type species of these insects. Being as firmly convinced as Emery and Forel that the subgenus as well as the subspecies and variety is, at least heuristically, a useful and valid category, I have recognized the subgeneric types as such in the following list and have not followed the example of those entomologists who, in similar lists, either ignore the subgeneric category or throw all or most subgeneric names into the synonymy. I have verified nearly all the bibliographic references cited below, but for a few of them from obscure and antiquated sources I have had to rely on Dalla Torre's "Catalogus Hymenopterorum." The list of genera and subgenera both living and fossil is, I believe, complete up to June, 1911.

Acamatus EMERY. Bull. Soc. Ent. Ital., XXVI, p. 184. 1894. (Subgenus of *Eciton.*)
Type: *Eciton* (*Acamatus*) *schmitti* Emery (by present designation).

Acanthognathus MAYR. Verh. zool. bot. Ges. Wien, XXXVII, p. 578. 1887.
Type: *Acanthognathus ocellatus* Mayr (monobasic).

Acantholepis MAYR. Europ. Formicid., p. 42. 1861.
Type: *Hypoclinea frauenfeldi* Mayr (monobasic).

Acanthomyops MAYR. Verh. zool. bot. Ges. Wien, XII, p. 699. 1862. (Subgenus of *Lasius.*)
Type: *Formica clavigera* Roger (by present designation).

Acanthomyrmex EMERY. Bull. Soc. Ent. France, LXI, p. CCLXXVI. 1892.
Type: *Acanthomyrmex luciolæ* Emery (designated by Bingham, 1903).

[1]Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 40.

Acanthoponera MAYR. Verh. zool. bot. Ges. Wien, XII, p. 732. 1862.
Type: *Ponera mucronata* Roger (by present designation).

Acanthostichus MAYR. Verh. zool. bot. Ges. Wien, XXXVII, p. 549. 1887.
Type: *Typhlopone serratula* F. Smith (monobasic).

Acrocœlia MAYR. Verh. zool. bot. Ver Wien, II, p. 146. 1852. (= *Cremastogaster.*)
Type: *Acrocœlia ruficeps* Mayr (= *Cremastogaster scutellaris* Oliv.).

Acromyrmex MAYR. Novara Reise Formicid., p. 83. 1865. (Subgenus of *Atta.*)
Type: *Formica hystrix* Latreille (= *Formica octospinosa* Reich).

Acropyga ROGER. Berlin. Ent. Zeitschr., VI, p. 242. 1862.
Type: *Acropyga acutiventris* Roger (monobasic).

Acrostigma EMERY. Mem. Accad. Sci. Bologna, (5) I, p. 575. 1891.
Type: *Acrostigma mayri* Emery (monobasic).

Acrostigma FOREL. Rev. Suisse Zool., X, p. 477. 1902. (= *Stigmacros;* Subgenus of *Acantholepis.*)
Type: *Acantholepis* (*Acrostigma*) *froggatti* Forel (first of four species by present designation).

Adelomyrmex EMERY. Termes. Füzetek, XX, p. 590. 1987.
Type: *Adelomyrmex biroi* Emery (monobasic).

Adlerzia FOREL. Rev. Suisse Zool., X, p. 445. 1902. (Subgenus of *Monomorium.*)
Type: *Monomorium* (*Adlerzia*) *froggatti* Forel (monobasic).

Ænictogiton EMERY. Bull. Soc. Ent. Ital., XXXIII, p. 49. 1901.
Type: *Ænictogiton fossiceps* Emery (monobasic).

Ænictus SHUCKARD. Ann. Mag. Nat. Hist., V, p. 266. 1840.
Type: *Ænictus ambiguus* Shuckard (designated by Shuckard, 1840).

Aëromyrma FOREL. Grandidier's Hist. Madagascar, XX, p. 198. 1891.
Type: *Aëromyrma nosindambo* Forel (monobasic).

Agrœcomyrmex WHEELER. Bull. Amer. Mus. Nat. Hist., XXVIII, p. 265. 1910.
Type: *Myrmica duisburgi* Mayr (monobasic).

Alaopone EMERY. Ann. Mus. Civ. Stor. Nat. Genova, XVI, p. 274. 1881. (Subgenus of *Dorylus.*)
Type: *Alaopone oberthueri* Emery = *Dorylus orientalis* Westwood (designated by Emery, 1910).[1]

Alfaria EMERY. Bull. Soc. Ent. Ital., XXVIII, p. 9. 1896.
Type: *Alfaria simulans* Emery (monobasic).

Allomerus MAYR. Verh. zool. bot. Ges. Wien, XXVII, p. 873. 1877.
Type: *Allomerus decemarticulatus* Mayr (by present designation).

Amblyopone ERICHSON. Arch. f. Naturg., VIII, p. 260. 1841.
Type: *Amblyopone australis* Erichson (monobasic).

Ancylognathus LUND. Ann. Sci. Nat., XXIII, p. 121. 1831. (= *Eciton.*)
Type: *Ancylognathus lugubris* Lund = ? *Eciton lugubre* F. Smith.

Aneleus EMERY. Termes. Füzetek, XXIII, p. 327. 1900. (Subgenus of *Pheidologeton.*)
Type: *Solenopsis similis* Mayr (monobasic).

[1] Ashmead, 1906, gives *A. carteri* Shuckard as the type, but this is evidently a misprint for *curtisi*, which is a synonym of *D. orientalis*.

Anergates FOREL. Denkschr. Schweiz Ges. Naturw., XXVI, pp. 29, 33, 35, 93. 1874.

Type: *Myrmica atratula* Schenck (monobasic).

Aneuretus EMERY. Ann. Soc. Ent. France, p. 241. 1893.

Type: *Aneuretus simoni* Emery (monobasic).

Anochetus MAYR. Europ. Formicid., p. 53. 1861.

Type: *Odontomachus ghilianii* Spinola (designated by Bingham, 1903).

Anomma SHUCKARD. Ann. Mag. Nat. Hist., V, p. 326. 1840. (Subgenus of *Dorylus*.)

Type: *Anomma burmeisteri* Shuckard = *Dorylus nigricans* Illiger (designated by Shuckard, 1840).

Aphænogaster MAYR. Verh. zool. bot. Ges. Wien, III, p. 107. 1853.

Type: *Aphænogaster sardoa* Mayr (designated by Bingham, 1903).

Aphomomyrmex EMERY. Ann. Soc. Ent. Belg., XLIII, p. 493. 1899.

Type: *Aphomomyrmex afer* Emery (by present designation).

Apsychomyrmex WHEELER. Bull. Amer. Mus. Nat. Hist., XXVIII, p. 261. 1910.

Type: *Apsychomyrmex myops* Wheeler (monobasic).

Apterostigma MAYR. Novara Reise Formicid., pp. 25 and 111. 1865.

Type: *Apterostigma pilosum* Mayr (monobasic).

Arotropus PROVANCHER. Natural. Canad., XII, p. 205. 1881. (= *Stigmatomma*.)

Type: *Arotropus binodosus* Provancher = *Stigmatomma pallipes* Haldeman (monobasic).

Asemorhoptrum MAYR. Europ. Formicid., p. 71. 1861. (= *Stenamma*.)

Type: *Asemorhoptrum lippulum* Mayr = *Stenamma westwoodi* Westwood (monobasic).

Atopogyne FOREL. Bull. Soc. Vaud. Sci. Nat. (5) XLVII, p. 342. 1911. (Subgenus of *Cremastogaster*.)

Type: *Cremastogaster* (*Atopogyne*) *hellenica* Forel (By present designation).

Atopomyrmex ERN. ANDRÉ. Rev. d'Entom., VIII, p. 226. 1889.

Type: *Atopomyrmex mocquerysi* Ern. André (monobasic).

Atta FABRICIUS. System. Piez., p. 421. 1804.

Type: *Formica cephalotes* Linn (first species by present designation).

Attopsis HEER. Denksch. Schweiz. Ges. Naturw., X, p. 155. 1850.

Type: *Attopsis longipennis* Heer (first species by present designation).

Azteca FOREL. Bull. Soc. Vaud. Sci. Nat., (2) XV, p. 384. 1878.

Type: *Tapinoma instabilis* F. Smith = *Liometopum ? xanthochroum* Roger (designated).

Basiceros SCHULZ, *nom. nov.* for Ceratobasis F. SMITH *nom. præocc.* Spolia. Hymenopt., p. 156. 1906.

Type: *Meranoplus singularis* F. Smith (monobasic).

Belonopelta MAYR. Sitzbr. Akad. Wiss. Wien, LXI, p. 394. 1870.

Type: *Belonopelta attenuata* Mayr (monobasic).

Bondroitia FOREL. Bull. Soc. Vaud. Sci. Nat. (5) XLVII, p. 398. 1911. (Subgenus of *Diplomorium*.)

Type: *Diplomorium* (*Bondroitia*) *lujæ* Forel. (First of two species, by present designation.)

Bothriomyrmex EMERY. Ann. Mus. Zool. Univ. Napoli, V, p. 117. 1865 (1869).
Type: *Bothriomyrmex costa* Emery = *Tapinoma meridionale* Roger (monobasic).

Bothroponera MAYR. Verh. zool. bot. Ges. Wien, XII, p. 717. 1862. (Subgenus of *Pachycondyla*).
Type: *Ponera pumicosa* Roger (designated by Emery, 1901).

Brachymyrmex MAYR. Ann. Soc., Nat. Modena, III, p. 163. 1868.
Type: *Brachymyrmex patagonicus* Mayr (monobasic).

Brachyponera EMERY. Ann. Soc. Ent. Belg., XLV, p. 43. 1901. (Subgenus of *Euponera*.)
Type: *Ponera sennaarensis* Mayr (designated by Emery, 1901).

Bradoponera MAYR. Beitr. Naturk. Preuss., I, p. 73. 1868.
Type: *Bradoponera meieri* Mayr (monobasic).

Calomyrmex EMERY. Zool. Jahrb. Abth. f. Syst., VIII, p. 772. 1895.
Type: *Formica laevissima* F. Smith (by present designation).

Calyptites SCUDDER. Rep. Progr. Geol. Surv. Canada for 1877, p. 270.
Type: *Calyptites antediluviana* Scudder (monobasic).

Calyptomyrmex EMERY. Ann. Mus. Civ. Stor. Nat. Genova, XXV, p. 472. 1887.
Type: *Calyptomyrmex beccarii* Emery (monobasic).

Campomyrma WHEELER. Science, n. s., XXXIII, p. 860. 1911. (Subgenus of *Myrma*.)
Type: *Polyrhachis clypeata* Mayr (designated by Wheeler, 1911).

Camponotus MAYR. Europ. Formicid., p. 35. 1861.
Type: *Formica ligniperda* Latreille (designated by Bingham, 1903).

Camptognatha WESTWOOD. Griffith. Anim. Kingd., XV, 5, p. 16. 1832. (= *Eciton*.)
Type: *Formica hamata* Fabricius (monobasic).

Cardiocondyla EMERY. Ann. Acc. Asp. Nat. Naples, Era 2, II, p. 20. 1869.
Type: *Cardiocondyla elegans* Emery (monobasic).

Carebara WESTWOOD. Ann. Mag. Nat. Hist., VI, p. 86. 1841.
Type: *Carebara lignata* Westwood (monobasic).

Carebarella EMERY. Bull. Soc. Ent. Ital., XXXVII, p. 137. 1905.
Type: *Carebarella bicolor* Emery (monobasic).

Cataglyphis FÖRSTER. Verh. Naturh. Ver. Preuss. Rheinl., VII, p. 493. 1850. (Subgenus of *Myrmecocystus*.)
Type: *Formica megalocola* Förster (worker); *Cataglyphis fairmairi* Förster (male) (monobasic).

Cataulacus F. SMITH. Trans. Ent. Soc. London, (2) II, p. 225. 1853.
Type: *Cataulacus taprobanæ* F. Smith (designated by Bingham, 1903).

Centromyrmex MAYR. Verh. zool. bot. Ges. Wien, XVI, p. 894. 1866.
Type: *Centromyrmex bohemanni* Mayr (monobasic).

Cephalotes LATREILLE. Hist. Nat. Crust. et Insect., III, p. 357. 1802. (= *Atta*.)
Type: *Formica cephalotes* Linné.

Cephaloxys F. SMITH. Journ. Proc. Linn. Soc. Zool., VIII, p. 76. 1864. (= *Strumigenys*.)
Type: *Cephaloxys capitata* F. Smith (monobasic).

Cerapachys F. SMITH. Journ. Proc. Linn. Soc. Zool., II, p. 74. 1857.
Type: *Cerapachys antennatus* F. Smith (monobasic).

Ceratobasis F. Smith. Journ. of Entom., I, p. 78. 1861. (= *Basiceros.*)
Type: *Meranoplus singularis* F. Smith (monobasic).

Ceratopheidole Pergande. Proc. Calif. Acad. Sci., (2) V, p. 889. 1895. (Subgenus of *Pheidole.*)
Type: *Pheidole* (*Ceratopheidole*) *granulata* Pergande (monobasic).

Champsomyrmex Emery. Ann. Soc. Ent. France, LX, p. 558, *nota.* 1891.
Type: *Odontomachus coquereli* Roger (monobasic).

Cheliomyrmex Mayr. Verh. zool. bot. Ges. Wien, XX, p. 968. 1870.
Type: *Cheliomyrmex nortoni* Mayr (monobasic).

Colobopsis Mayr. Europ. Formicid, p. 38. 1861. (Subgenus of *Camponotus.*)
Type: *Formica truncata* Spinola.

Condylodon Lund. Ann. Sci. Nat., XXIII, p. 131. 1831. (= *Pseudomyrma.*)
Type: *Condylodon audouini* Lund.

Cosmacetes Spinola. Mem. Accad. Torino, (2) XIII, p. 70. 1851. (= *Typhlopone.*)
Type: *Cosmacetes omalinus* Spinola = *Typhlopone fulva* Westwood.

Cratomyrmex Emery. Ann. Soc. Ent. France, p. 572. 1892.
Type: *Cratomyrmex regalis* Emery (monobasic).

Cremastogaster Lund. Ann. Sci. Nat., XXIII, p. 132. 1831.
Type: *Formica scutellaris* Olivier (designated by Bingham, 1903).

Cryptocerus Latreille. Hist. Nat. Ins., XIII, p. 260. 1805.
Type: *Formica atrata* Linné (monobasic).

Cryptopone Emery. Bull. Soc. Ent. France, LXI, p. CCLXXV. 1892.
Type: *Amblyopone ? testacea* Motschulsky (monobasic).

Ctenopyga Ashmead. Canad. Ent., XXXVII, p. 382. 1905.
Type: *Ctenopyga townsendi* Ashmead (designated by Ashmead, 1905).

Cylindromyrmex Mayr. Verh. zool. bot. Ges. Wien, XX, p. 967. 1870.
Type: *Cylindromyrmex striatus* Mayr (monobasic).

Cyphomyrmex Mayr. Verh. zool. bot. Ges. Wien, XII, p. 690. 1862.
Type: *Cryptocerus ? rimosus* Spinola (by present designation).

Cysias Emery. Rend. Accad. Sci. Bologna, n. s., VI, p. 24. 1902. (Subgenus of *Cerapachys.*)
Type: *Cerapachys papuanus* Emery (designated by Emery, 1902).

Daceton Perty. Delect. Animal Artic. Brasil, p. 136. 1833.
Type: *Formica armigera* Latreille (monobasic).

Dacryon Forel. Ann. Soc. Ent. Belg., XXXIX, p. 421. 1895.
Type: *Dacryon omniparens* Forel (monobasic).

Decacrema Forel. Ann. Soc. Ent. Belg., LIV, p. 18. 1910. (Subgenus of *Cremastogaster.*)
Type: *Cremastogaster schencki* Forel (by present designation).

Decamera Roger. Berlin. Ent. Zeitschr., VII, p. 166. 1863. (= *Myrmelachista.*)
Type: *Decamera nigella* Roger (monobasic).

Dendromyrmex Emery. Zool. Jahrb. Abth. f. Syst., VIII, p. 772. 1895.
Type: *Camponotus chartifex* F. Smith (by present designation).

Diacamma Mayr. Verh. zool. bot. Ges. Wien, XII, p. 718. 1862.
Type: *Ponera rugosa* Le Guillou (designated by Bingham, 1903).

Dichothorax Emery. Zool. Jahrb. Abth. f. Syst., VIII, p. 323. 1894. (Subgenus of *Leptothorax.*)
Type: *Leptothorax* (*Dichothorax*) *pergandei* Emery (first of two species by present designation).

Dichthadia GERSTÄCKER. Stettin. Ent. Zeitg., XXIV, p. 093. 1863. (Subgenus of *Dorylus*.)
  Type: *Dichthadia glaberrima* Gerstäcker = *Dorylus laevigatus* F. Smith (monobasic).[4]

Dicroaspis EMERY. Ann. Soc. Ent. Belg., LII, p. 184. 1908.
  Type: *Dicroaspis cryptocera* Emery (monobasic).

Dilobocondyla SANTSCHI. Le Naturaliste, XXXII, p. 283. 1910.
  Type: *Atopomyrmex selebensis* Emery (by present designation).

Dimorphomyrmex ERN. ANDRÉ. Mem. Soc. Zool. France, V, p. 49. 1892.
  Type: *Dimorphomyrmex janeti* Ern. André (monobasic).

Dinomyrmex ASHMEAD. Canad. Entom., XXXVII, p. 384. 1905. (= *Camponotus*.)
  Type: *Formica gigas* Latreille (designated by Ashmead, 1905).

Dinoponera ROGER. Berlin. Ent. Zeitschr., V, p. 37. 1861.
  Type: *Ponera grandis* Guérin (monobasic).

Diplomorium MAYR. Ann. K. K. Naturhist. Hofmus, XVI, p. 16. 1907.
  Type: *Diplomorium longipenne* Mayr (monobasic).

Diplorhoptrum MAYR. Verh. zool. bot. Ver. Wien, V, p. 449. 1855. (= *Solenopsis*.)
  Type: *Formica fugax* Latreille (monobasic).

Discothyrea ROGER. Berlin. Ent. Zeitschr., VII, p. 176. 1863.
  Type: *Discothyrea testacea* Roger (monobasic).

Doleromyrma FOREL. Ann. Mus. Nat. Hungar., V, p. 28. 1907. (Subgenus of *Tapinoma*.)
  Type: *Tapinoma (Doleromyrma) darwiniana* Forel (monobasic).

Dolichoderus LUND. Ann. Sci. Nat., XXIII, p. 130. 1831.
  Type: *Dolichoderus attelaboides* Lund (monobasic).

Dorylus FABRICIUS. Ent. Syst., II, pp. 194 and 365. 1793.
  Type: *Vespa helvola* Linné (designated by Shuckard, 1840).

Dorymyrmex MAYR. Sitzb. Akad. Wiss. Wien. LIII. p. 494. 1866.
  Type: *Formica flavescens* Fabricius (monobasic).

Drepanognathus F. SMITH. Catal. Hymen. Brit. Mus., VI, p. 81. 1858.
  Type: *Harpegnathus saltator* Jerdon (designated by Bingham, 1903).

Echinopla F. SMITH. Journ. Proc. Linn. Soc. Zool., II, p. 79. 1857.
  Type: *Echinopla melanarctos* F. Smith (first species by present designation).

Eciton LATREILLE. Hist. Nat. Crust. et Ins., IV, p. 130. 1802.
  Type: *Formica hamata* Fabricius (designated by Emery, 1910).

Ecphorella FOREL. Ann. Soc. Ent. Belg., LIII, p. 65. 1909. (Subgenus of *Tapinoma*.)
  Type: *Ecphorella wellmani* Forel (monobasic).

Ectatomma F. SMITH. Cat. Hymen. Brit. Mus., VI, p. 102. 1858.
  Type: *Formica tuberculata* Oliver (designated by Bingham, 1903).

Ectomomyrmex MAYR. Tijdscr. v. Ent., X, p. 83. 1867. (Subgenus of *Pachycondyla*.)
  Type: *Ectomomyrmex javanus* Mayr (designated by Bingham, 1903).

[4] Not *D. furcata*, as stated by Ashmead, 1906.

Electromyrmex Wheeler. Ants, their Struct., Develop. and Behav., p. 164. 1910.
Type: *Electromyrmex klebsi* Wheeler (monobasic).

Emeryella Forel. Ann. Soc. Ent. Belg., XLV, p. 334. 1901.
Type: *Emeryella schmitti* Forel (monobasic).

Emeryia Forel. C. R. Soc. Ent. Belg., p. CX. 1890. (=*Cardiocondyla.*)
Type: *Emeryia wroughtoni* Forel (monobasic).

Engramma Forel. Ann. Soc. Ent. Belg., XLIX, p. 180. 1905.
Type: *Engramma lujæ* Forel (monobasic).

Enneamerus Mayr. Beitr. Naturk. Preuss., I, p. 98. 1868.
Type: *Enneamerus reticulatus* Mayr (monobasic).

Ephebomyrmex Wheeler. Psyche, IX, p. 390. 1902. (Subgenus of *Pogonomyrmex.*)
Type: *Pogonomyrmex nægelii* Forel (by present designation).

Epœcus Emery. Ann. Soc. Ent. France, V, C. R., p. XXLXXVI. 1892; Zool. Jahrb. Abth. f. Syst., VIII, p. 272. 1894.
Type: *Epœcus pergandei* Emery (monobasic).

Epipheidole Wheeler. Bull. Amer. Mus. Nat. Hist., XX, p. 14. 1904.
Type: *Epipheidole inquilina* Wheeler (monobasic).

Epitritus Emery. Bull. Soc. Ent. Ital., I, p. 136. 1869.
Type: *Epitritus argiolus* Emery (monobasic).

Epixenus Emery. Deutsch. Ent. Zeitschr., p. 556. 1908.
Type: *Epixenus andrei* Emery = "abnormal female" of *Monomorium venustum* Ern. André (first of two species by present designation).

Epopostruma Forel. Ann. Soc. Ent. Belg., XXXIX, p. 422. 1895. (Subgenus of *Strumigenys.*)
Type: *Strumigenys (Epopostruma) quadrispinosa* Forel (first of two species by present designation).

Erebomyrma Wheeler. Biol. Bull., IV, p. 138. 1903.
Type: *Erebomyrma longi* Wheeler (monobasic).

Escherichia Forel. Zool. Jahrb. Abth. f. Syst., XXIX, p. 245. 1910.
Type: *Escherichia brevirostris* Forel (monobasic).

Eumecopone Forel. Ann. Soc. Ent. Belg., XLV, p. 335. 1901. (Subgenus of *Neoponera.*)
Type: *Neoponera (Eumecopone) agilis* Forel (monobasic).

Euponera Forel. Grandidier's Hist. Madagascar, XX, p. 126. 1891.
Type: *Ponera sikoræ* Forel (monobasic).

Euprenolepis Emery. Ann. Soc. Ent. Belg., L, p. 134. 1906. (Subgenus of *Prenolepis.*)
Type: *Prenolepis procera* Emery (designated by Emery, 1906).

Eusphinctus Emery. Ann. Soc. Ent. France, p. CCLXXV. 1892. (Subgenus of *Sphinctomyrmex.*)
Type: *Eusphinctus furcatus* Emery (monobasic).

Eutetramorium Emery. Bull. Soc. Ent. Ital., XXXI, p. 281. 1899.
Type: *Eutetramorium mocquerysi* Emery (first of two species by present designation).

Forelius Emery. Zeitschr. f. wiss. Zool., XLVI, p. 389. 1888.
Type: *Iridomyrmex maccooki* Forel (monobasic).

Formica LINNÉ. System. Nat., Ed. 10, p. 579. 1758.
Type: *Formica rufa* Linné (designated by Bingham, 1903).
Formicina SHUCKARD. Swainson & Shuckard's Hist. Nat. Arrang. of Insects, p. 172. 1840. (= *Formica*.)
Type: *Formica rufa* Linné (by present designation).
Formicoxenus MAYR. Verh. zool. bot. Ver. Wien, V, p. 413. 1855.
Type: *Myrmica nitidula* Nylander (monobasic).
Froggattella FOREL. Rev. Suisse Zool., X, p. 459. 1902.
Type: *Acantholepis kirbyi* Lowne = *Hypoclinea kirbyi* Mayr (monobasic).
Gesomyrmex MAYR. Beitr. Naturk. Preuss., I, p. 50. 1868.
Type: *Gesomyrmex hœrnesi* Mayr (monobasic).
Gigantiops ROGER. Berlin. Ent. Zeitschr., VI, p. 287. 1862.
Type: *Formica destructor* Fabricius (monobasic).
Glyptomyrmex FOREL. Bull. Soc. Vaud. Sci. Nat., (2) XX, p. 365. 1884. (= *Myrmicocrypta*.)
Type: *Glyptomyrmex dilaceratus* Forel (monobasic).
Gnamptogenys ROGER. Berlin. Ent. Zeitschr., VII, p. 174. 1863. (Subgenus of *Ectatomma*.)
Type: *Ectatomma cincinnatum* Mayr (by present designation).
Goniomma EMERY. Zool. Jahrb. Abth. f. Syst., VIII, p. 298. 1895.
Type: *Aphænogaster blanci* Ern. André (monobasic).
Goniothorax EMERY. Bull. Soc. Ent. Ital., XXVIII, p. 26. 1896. (Subgenus of *Leptothorax*.)
Type: *Leptothorax vicinus* Mayr (by present designation).
Hagensia FOREL. Rev. Suisse Zool., IX, p. 333. 1901. (Subgenus of *Megaponera*.)
Type: *Megaloponera* (*Hagensia*) *havilandi* Forel (monobasic).
Hagiomyrma WHEELER. Science n. s., XXXIII, p. 860. 1911. (Subgenus of *Myrma*.)
Type: *Formica ammon* Fabricius (designated by Wheeler, 1911).
Hagioxenus FOREL. Ann. Soc. Ent. Belg., LIV, p. 8. 1910.
Type: *Hagioxenus schmitzi* Forel (monobasic).
Harpagoxenus FOREL. Ann. Soc. Ent. Belg., XXXVII, p. 167. 1893. *Nom. nov.* for **Tomognathus** MAYR, *nom. praeocc.* 1861.
Type: *Tomognathus sublævis* Nylander (monobasic).
Harpegnathus JERDON. Madras Journ. Litt. and Sci., XVII, p. 116. 1851. (= *Drepanognathus*.)
Type: *Drepanognathus cruentatus* Smith = *Harpegnathus saltator* Jerdon (by present designation).
Hemioptica ROGER. Berlin. Ent. Zeitschr., VI, p. 238. 1862. (Subgenus of *Myrma*.)
Type: *Hemioptica scissa* Roger (monobasic).
Heptacondylus F. SMITH. Catalog. Hymen. Brit. Mus., VI, p. 141. 1858. (= *Myrmicaria*.)
Type: *Heptacondylus subcarinatus* F. Smith = *Myrmica fodiens* Jerdon (first of three species by present designation).
Heteroponera MAYR. Verh. zool. bot. Ges. Wien, XXXVII, p. 532. 1887. (= *Acanthoponera*.)
Type: *Heteroponera carinifrons* Mayr (monobasic).

Holcomyrmex Mayr. Verh. zool. bot. Ges. Wien, XXVIII, p. 671. 1878. (Subgenus of *Monomorium*.)
Type: *Holcomyrmex scabriceps* Mayr (designated by Bingham, 1903).

Holcoponera Mayr. Verh. zool. bot. Ges. Wien, XXXVII, p. 540. 1887. (Subgenus of *Ectatomma*.)
Type: *Ectatomma* (*Holcoponera*) *striatulum* Mayr (by present designation).

Hoplomyrmus Gerstäcker. Monatschr. Akad. Wiss. Berlin, p. 261. 1858. (=*Myrma*.)
Type: *Hoplomyrmus schistaceus* Gerstäcker (monobasic).

Huberia Forel. C. R. Soc. Ent. Belg., p. CV. 1890.
Type: *Tetramorium striatum* F. Smith (monobasic).

Hypochira Buckley. Proc. Ent. Soc. Phila., VI, p. 169. 1866. (=*Formica*.)
Type: *Formica* (*Hypochira*) *subspinosa* Buckley (monobasic).

Hypoclinea (Förster) Mayr. Verh. zool. bot. Ver. Wien, V, p. 377. 1855. (Subgenus of *Dolichoderus*.)
Type: *Formica quadripunctata* Linné (second species by present designation).

Hypopomyrmex Emery. Mem. Accad. Sci. Bologna, (5) I, p. 574. 1891.
Type: *Hypopomyrmex bombiccii* Emery (monobasic).

Imhoffia Heer. Verh. Schweiz. Naturf. Ges., p. 78. 1849.
Type: *Imhoffia nigra* Heer (monobasic).

Iridomyrmex Mayr. Verh. zool. bot. Ges. Wien, XII, p. 702. 1862.
Type: *Formica detecta* F. Smith (designated by Bingham, 1903).

Ischnomyrmex Mayr. Verh. zool. bot. Ges. Wien, XII, p. 738. 1862. (Subgenus of *Aphænogaster*.)
Type: *Myrmica longipes* F. Smith (monobasic).

Janetia Forel. Biol. Centr. Amer. Hymen., III, p. 61, *nota*. 1899. (Subgenus of *Pogonomyrmex*.)
Type: *Pogonomyrmex* (*Janetia*) *mayri* Forel (monobasic).

Labidogenys Roger. Berlin. Ent. Zeitschr., VI, p. 249. 1862. (=*Strumigenys*.)
Type: *Labidogenys lyroessa* Roger (monobasic).

Labidus Jurine. Nouv. Meth. Class Hymén., p. 282. 1807. (Subgenus of *Eciton*.)
Type: *Labidus latreillei* Jurine = male *Eciton cæcum* (Latreille) = *Formica cæca* Latreille (designated by Shuckard, 1840).

Lachnomyrmex Wheeler. Bull. Amer. Mus. Nat. Hist., XXVIII, p. 263. 1910.
Type: *Lachnomyrmex scrobiculatus* Wheeler (monobasic).

Lampromyrmex Mayr. Beitr. Naturk. Preuss., I, p. 93. 1868.
Type: *Lampromyrmex gracillimus* Mayr (monobasic).

Laparomyrmex Emery. Ann. Mus. Civ. Stor. Nat. Genova (2), V, p. 37. 1887. (=*Liomyrmex*.)
Type: *Laparomyrmex gestroi* Emery (monobasic).

Lasiophanes Emery. Act. Soc. Sci. Chili, V, p. 16. 1895. (Subgenus of *Melophorus*.)
Type: *Formica nigriventris* Spinola (by present designation).

Lasius Fabricius. System. Piezat., p. 415. 1804.
Type: *Formica nigra* Linné (designated by Bingham, 1903).

Leptalea (Klug) Erichson. Arch. f. Naturg., V, p. 309. 1839. (= *Pseudomyrma*.)
Type: *Formica gracilis* Fabricius (monobasic).
Leptanilla Emery. Bull. Soc. Ent. Ital., II, p. 196. 1870.
Type: *Leptanilla revelieri* Emery (monobasic).
Leptogenys Roger. Berlin. Ent. Zeitschr., V, p. 41. 1861.
Type: *Leptogenys falcigera* Roger (designated by Bingham, 1903).
Leptomyrma Motschulsky. Bull. Soc. Nat Mosc., XXXVI, p. 17. 1863. (= *Pheidole*.)
Type: *Leptomyrma gracilipes* Motschulsky (monobasic).
Leptomyrmex Mayr. Verh. zool. bot. Ges. Wien, XII, p. 695. 1862.
Type: *Formica erythrocephala* Fabricius (monobasic).
Leptothorax Mayr. Verh. zool. bot. Ges. Wien, V, p. 431. 1855.
Type: *Formica acervorum* Fabricius (by present designation).
Linepithema Mayr. Sitzb. Akad. Wiss. Wien, LIII, p. 496. 1866.
Type: *Linepithema fuscum* Mayr (monobasic).
Liometopum Mayr.. Europ. Formicid., p. 38 1861.
Type: *Formica microcephala* Panzer (monobasic).
Liomyrmex Mayr. Novara Reise Formicid., p. 23. 1865.
Type: *Myrmica caeca* F. Smith (monobasic).
Lioponera Mayr. Verh. zool. bot. Ges. Wien, XXVIII, p. 666. 1878.
Type: *Lioponera longitarsus* Mayr (monobasic).
Lobopelta Mayr. Verh. zool. bot. Ges. Wien, XII, p. 733. 1862. (Subgenus of *Leptogenys*.)
Type: *Ponera diminuta* F. Smith (designated by Bingham, 1903).
Lonchomyrmex Mayr. Jahrb. Geol. Reichsanst. Wien, XVII, p. 61. 1867.
Type: *Formica freyeri* Heer (monobasic).
Lophomyrmex Emery. Ann. Mus. Civ. Stor. Nat. Genova, XXII, p. 114. 1892.
Type: *Œcodoma quadrispinosa* Jerdon (monobasic).
Lordomyrma Emery. Termes. Füzetek. XX, p. 591. 1897.
Type: *Lordomyrma furcifera* Emery (first of two species by present designation).
Machomyrma Forel. Ann. Soc. Ent. Belg., XXXIX, p. 125 1895. (Subgenus of *Liomyrmex*.)
Type: *Liomyrmex (Machomyrma) dispar* Forel (monobasic).
Macromischa Roger. Berlin. Ent. Zeitschr., VII, p. 184. 1863.
Type: *Macromischa purpurata* Roger (first species by present designation).
Manica Jurine. Nouv. Méth. Class. Hymén., p. 276. 1807. (= *Myrmica*.)
Type: *Formica rubida* Latreille (by present designation).
Martia Forel. Ann. Mus. Nat. Hungarici, V, p. 20. 1907. (Subgenus of *Monomorium*.)
Type: *Monomorium (Martia) vezenyii* Forel (monobasic).
Mayria Forel. Bull. Soc. Vaud. Sci. Nat., (2) XV, p. 369. 1878.
Type: *Mayria madagascariensis* Forel (monobasic).
Mayriella Forel. Rev. Suisse Zool., X, p. 452. 1902.
Type: *Mayriella abstinens* Forel (monobasic).
Mayromyrmex Ashmead. Canad. Ent., XXXVII, p. 381. 1905. (= *Eciton*.)
Type: *Labidus fargeaui* Shuckard = male *Eciton quadriglume* Haliday (designated by Ashmead, 1905).

Megalomyrmex Forel. Bull. Soc. Vaud. Sci. Nat., (2) XX, p. 56. 1884.
Type: *Formica bituberculata* Fabricius (by present designation).

Megaloponera Emery. Ann. Mus. Civ. Stor. Nat. Genova, IX, p. 368. 1877. (= *Megaponera.*)
Type: *Formica fœtens* Fabricius (monobasic).

Megaponera Mayr. Verh. zool. bot. Ges. Wien, XII, p. 734. 1862.
Type: *Formica fœtens* Fabricius (monobasic).

Melissotarsus Emery. Ann. Mus. Civ. Stor. Nat. Genova, IX. p. 378. 1877.
Type: *Melissotarsus beccarii* Emery (monobasic).

Melophorus Lubbock. Journ. Linn. Soc. Zool., XVIII, p. 51. 1883.
Type: *Melophorus bagoti* Lubbock (monobasic).

Meranoplus F. Smith. Trans. Ent. Soc. London, (2) II, p. 224. 1854
Type: *Cryptocerus bicolor* Guérin (designated by Bingham, 1903).

Mesoponera Emery. Ann. Soc. Ent. Belg., XLV, p. 43. 1901. (Subgenus of *Euponera.*)
Type: *Ponera caffraria* F. Smith (designated by Emery, 1901).

Mesoxena F. Smith. Journ. Proc. Linn. Soc. Zool., IV, Suppl., p. 106. 1860.
Type: *Mesoxena mistura* F. Smith (monobasic).

Messor Forel. Ann. Soc. Ent. Belg., XXXIV, C. R., p. LXVIII. 1890.
Type: *Formica barbara* Linné (designated by Bingham, 1903).

Micromyrma Dufour. Ann. Soc. Ent. France, (2) V, p. 60. 1857. (= *Tapinoma.*)
Type: *Formica erratica* Latreille (monobasic).

Mictoponera Forel. Ann. Soc. Ent. Belg., XLV, p. 372. 1901. (Subgenus of *Ectatomma.*)
Type: *Ectatomma* (*Mictoponera*) *diehli* Forel (monobasic).

Mœllerius Forel. Ann. Soc. Ent. Belg., XXXVII, p. 589. 1893. (Subgenus of *Atta.*)
Type: *Acromyrmex landolti* Forel (by present designation).

Monacis Roger. Berlin. Ent. Zeitschr., VI, p. 233. 1862. (Subgenus of *Dolichoderus.*)
Type: *Formica bispinosa* Oliv. = *Formica fungosa* Fabr. (by present designation).

Monocombus Mayr. Verh. zool. bot. Ver. Wien, V, p. 381. 1855. (= *Cataglyphis.*)
Type: *Formica viatica* Fabricius (monobasic).

Monomorium Mayr. Verh. zool. bot. Ver. Wien, V, p. 452. 1855.
Type: *Monomorium minutum* Mayr (monobasic).

Mycetosoritis Wheeler. Bull. Amer. Mus. Nat. Hist., XXIII, p. 714. 1907. (Subgenus of *Atta.*)
Type: *Atta* (*Mycetosoritis*) *hartmani* Wheeler (monobasic).

Mychothorax Ruzsky. Formica Imp. Rossici, p. 107. 1905. (= *Leptothorax.*)
Type: *Formica acervorum* Fabricius (first species by present designation).

Mycocepurus Forel. Trans. Ent. Soc. London, IV, p. 369. 1893.
Type: *Mycocepurus smithi* Forel (by present designation).

Myopias Roger. Berlin. Ent. Zeitschr., V, p. 39. 1861.
Type: *Myopias amblyops* Roger (monobasic).

Myopopone Roger. Berlin. Ent. Zeitschr., V. p. 49. 1861.
Type: *Amblyopone castanea* F. Smith var. *maculata* Roger (monobasic).

Myrma BILBERG. Enumer. Insect., p. 104. 1820.
Type: *Formica militaris* Fabricius (by present designation).

Myrmecia FABRICIUS. System. Piezat., p. 423. 1804.
Type: *Formica gulosa* Fabricius (by present designation).

Myrmecina CURTIS. Brit. Entom., IV, p. 226. 1829.
Type: *Myrmecina latreillei* Curtis (monobasic).

Myrmecocystus WESMAEL. Bull. Acad. Sci. Brux., V, p. 770. 1838.
Type: *Myrmecocystus mexicanus* Wesmael (monobasic).

Myrmecopsis F. SMITH. Journ. Proc. Linn. Soc., VIII, p. 68. 1864.
Type: *Myrmecopsis respiciens* F. Smith (monobasic).

Myrmecorhynchus ERN. ANDRÉ. Rev. d'Entom, XV, p. 253. 1896.
Type: *Myrmecorhynchus emeryi* Ern. André (monobasic).

Myrmelachista ROGER. Berlin. Ent. Zeitschr., VII, p. 162. 1863.
Type: *Myrmelachista kraatzi* Roger (monobasic).

Myrmex GUÉRIN. Iconogr. Regn. Anim., VII, Insect., p. 428. 1845. (=*Pseudomyrma.*)
Type: *Pseudomyrma* (*Myrmex*) *perboscii* Guérin.

Myrmica LATREILLE. Hist. Nat. Crust. et Insect., IV, p. 131. 1802.
Type: *Formica rubra* Linn (by present designation).

Myrmicaria SAUNDERS. Trans. Ent. Soc. London, III, p. 57. 1841.
Type: *Myrmicaria brunnea* Sanders (monobasic).

Myrmicocrypta F. SMITH. Journ. of Ent., I, p. 73. 1860.
Type: *Myrmicocrypta squamosa* F. Smith (monobasic).

Myrmoteras FOREL. Ann. Soc. Ent. Belg., XXXVII, p. 607. 1893.
Type: *Myrmoteras binghami* Forel (monobasic).

Myrmoxenus RUZSKY. Zool. Jahrb. Abth. f. Syst., XVII, p. 474. 1902.
Type: *Myrmoxenus gordiagini* Ruzsky (monobasic).

Myrmus SCHENCK. Stettin. Ent. Zeitg., XIV, p. 299. 1853. (=*Strongylognathus.*)
Type: *Myrmus emarginatus* Schenck = *Eciton ? testaceum* Schenck (monobasic).

Mystrium ROGER. Berlin. Ent. Zeitschr., VI, p. 245. 1862.
Type: *Mystrium mysticum* Roger (monobasic).

Neoponera EMERY. Ann. Soc. Ent. Belg., XLV, p. 40. 1901.
Type: *Formica villosa* Fabricius (designated by Emery, 1901).

Nesomyrmex WHEELER. Bull. Amer. Mus. Nat. Hist., XXVIII, p. 259. 1910.
Type: *Nesomyrmex clavipilis* Wheeler (monobasic).

Notoncus EMERY. Ann. Soc. Ent. Belg., XXXIX, p. 352. 1895.
Type: *Camponotus ectatommoides* Forel (monobasic).

Nycteresia ROGER. Berlin. Ent. Zeitschr., V, p. 21. 1861. (=*Eciton.*)
Type: *Nycteresia caeca* Roger = *Formica caeca* Latreille (monobasic).

Nylanderia EMERY. Ann. Soc. Ent. Belg., L, p. 134. 1906. (Subgenus of *Prenolepis.*)
Type: *Prenolepis vividula* Nylander (designated by Emery, 1906).

Ochetomyrmex MAYR. Verh. zool. bot. Ges. Wien, XXVII, p. 871. 1877.
Type: *Ochetomyrmex semipolitus* Mayr (monobasic).

Ocymyrmex EMERY. Bull. Soc. Ent. Ital., XVIII, p. 364. 1886.
Type: *Ocymyrmex barbiger* Emery (monobasic).

Odontomachus LATREILLE. Hist. Nat. Crust. et Insect., IV, p. 128. 1802.
Type: *Formica hæmatoda* Linné (monobasic).

Odontomyrmex ERN. ANDRÉ. Rev. d'Entom., XXIII, p. 207. 1904.
Type: *Odontomyrmex quadridentatus* Ern. André (monobasic).

Odontoponera MAYR. Verh. zool. bot. Ges. Wien, XII, p. 717. 1862.
Type: *Ponera denticulata* F. Smith = *Ponera transversa* F. Smith (monobasic).

Œcodoma LATREILLE. Nouv. Dict. Hist. Nat., XXIII, p. 50. 1818. (=*Atta.*)
Type: *Formica cephalotes* Linné (by present designation).

Œcophthora HEER. Hausameise Madeiras, p. 15. 1852. (=*Pheidole.*)
Type: *Œcophthora pusilla* Heer = *Formica megacephala* Fabricius (monobasic).

Œcophylla F. SMITH. Journ.-Linn. Soc. Zool., V, p. 101. 1861.
Type: *Formica virescens* Fabricius (designated by Bingham, 1903).

Oligomyrmex MAYR. Tydscr. v. Ent., X, p. 110.
Type: *Oligomyrmex concinnus* Mayr (monobasic).

Onychomyrmex EMERY. Ann. Soc. Ent. Belg., XXXIX, p. 349. 1895.
Type: *Onychomyrmex hedleyi* Emery (monobasic).

Oöceræa ROGER. Berlin. Ent. Zeitschr., VI, p. 248. 1862. (Subgenus of *Cerapachys.*)
Type: *Oöceræa fragosa* Roger (monobasic).

Ophthalmopone FOREL. C. R. Soc. Ent. Belg., p. CXII. 1890.
Type: *Ophthalmopone berthoudi* Forel (monobasic).

Opisthopsis EMERY. Ann. Soc. Ent. Belg., XXXIX, p. 353. 1895. *Nom. nov.* for *Myrmecopsis nom. præocc.*
Type: *Myrmecopsis respiciens* F. Smith (monobasic).

Orectognathus F. SMITH. Trans. Ent. Soc. Lond., (2) II, p. 227. 1854.
Type: *Orectognathus antennatus* F. Smith (monobasic).

Orthonotomyrmex ASHMEAD. Proc. Ent. Soc. Wash., VIII, p. 31. 1906. *Nov. nom.* for **Orthonotus** *nom. præocc.* (=*Camponotus.*)
Type: *Formica sericea* Fabricius (designated by Ashmead, 1905).

Orthonotus ASHMEAD. Canad. Ent., XXXVII, p. 384. 1905. *Nom. præocc.* (=*Orthonotomyrmex* = *Camponotus.*)
Type: *Formica sericea* Fabricius (designated by Ashmead, 1905).

Otomyrmex FOREL. Grandidier's Hist. Madagascar, XX, p. 147. 1891. (Subgenus of *Calaulacus.*)
Type: *Calaulacus oberthueri* Emery (monobasic).

Oxygyne FOREL. Ann. Soc. Ent. Belg., XLV, p. 376. 1901. (Subgenus of *Cremastogaster.*)
Type: *Cremastogaster (Oxygyne) daisyi* Forel (by present designation).

Oxyopomyrmex ERN. ANDRÉ. Ann. Soc. Ent. France, V, p. 72. 1880.
Type: *Oxyopomyrmex oculatus* Ern. André (monobasic).

Pachycondyla F. SMITH. Catalog. Hymen. Brit. Mus., VI, p. 105. 1858.
Type: *Formica crassinoda* Latreille (designated by Emery, 1901).

Pædalgus FOREL. Escherich's Termitenleben auf Ceylon, p. 217. 1911.
Type: *Pædalgus escherichi* Forel (monobasic).

Paltothyreus MAYR. Verh. zool. bot. Ges. Wien, XII, p. 735. 1862.
Type: *Formica tarsata* Fabricius (monobasic).

Paraponera F. SMITH. Catalog. Hymen. Brit. Mus., VI, p. 100. 1858.
Type: *Formica clavata* Fabricius (monobasic).

Parasyscia EMERY. In Ern. André, Spec. Hymén. Europ., II, p. 235. 1882. (Subgenus of *Cerapachys.*)
Type: *Parasyscia piochardi* Emery (monobasic).

Paratrechina MOTSCHULSKY. Bull. Soc. Nat. Moscou, XXXVI, p. 13 1863. (= *Prenolepis.*)
Type: *Paratrechina currens* Motschulsky = *Formica longicornis* Latreille (monobasic).

Pedetes BERNSTEIN. Verh. zool. bot. Ges. Wien, XI, Sitzb., p. 7. 1861. (= *Odontomachus.*)
Type: *Pedetes macrorhynchus* Bernstein (*nomen nudum*).

Phacota ROGER. Berlin. Ent. Zeitschr., VI, p. 260. 1862.
Type: *Phacota sicheli* Roger (monobasic).

Phasmomyrmex STITZ. Mittheil. Zool. Mus. Berlin, V, p. 146. 1910. (= *Camponotus.*)
Type: *Phasmomyrmex sericeus* Stitz = *Camponotus buchneri* Forel.

Pheidolacanthinus F. SMITH. Journ. Linn. Soc. Zool., VIII, p. 75. 1864.
Type: *Pheidolacanthinus armatus* F. Smith (monobasic).

Pheidole WESTWOOD. Ann. Mag. Nat. Hist., VI, p. 87. 1841.
Type: *Atta providens* Sykes (designated by Bingham, 1903).

Pheidologeton MAYR. Verh. zool. bot. Ges. Wien, XII, p. 750. 1862.
Type: *Pheidole ocellifera* F. Smith = *Œcodoma diversa* Jerdon (designated by Bingham, 1903).

Phyracaces EMERY. Rend. Accad. Sci. Ist. Bologna, n. s., VI, p. 23. 1902. (Subgenus of *Cerapachys.*)
Type: *Cerapachys mayri* Forel (designated by Emery, 1902).

Physatta F. SMITH. Catalog. Hymen. Brit. Mus., VI, p. 171. 1858. (= *Myrmicaria.*)
Type: *Physatta dromedarius* F. Smith = *Heptacondylus carinatus* F. Smith (first of four species by present designation).

Plagiolepis MAYR. Europ. Formicid., p. 42. 1861.
Type: *Formica pygmæa* Latreille (monobasic).

Platythyrea ROGER. Berlin. Ent. Zeitschr., VII, p. 172. 1863.
Type: *Pachycondyla punctata* F. Smith (designated by Bingham 1903).

Plectroctena F. SMITH. Catalog. Hymen. Brit. Mus., VI, p. 102. 1858.
Type: *Plectroctena mandibularis* F. Smith = *Formica caffra* (Klug) Spinola (monobasic).

Podomyrma F. SMITH. Journ. Proc. Linn. Soc. Zool., III, p. 135. 1858
Type: *Podomyrma femorata* F. Smith (first species, by present designation).

Pogonomyrmex MAYR. Annu. Soc. Nat. Modena, III, p. 169. 1868.
Type: *Formica badia* Latreille (by present designation).

Polyergus LATREILLE. Hist. Nat. Crust. Insect., XIII, p. 256. 1805.
Type: *Formica rufescens* Latreille (monobasic).

Polyrhachis F. SMITH. Journ. Proc. Linn. Soc. Zool., II, p. 58. 1858. (Subgenus of *Myrma.*)
Type: *Formica bihamata* Drury (designated by Smith, 1858).

Ponera LATREILLE. Hist. Nat. Crust. Insect., IV, p. 128. 1802.
Type: *Formica coarctata* Latreille (monobasic).
Poneropsis HEER. Denkschr. Schweiz. Ges. Naturw., XXII, p. 19. 1867.
Type: *Ponera fuliginosa* Heer (by present designation).
Prenolepis MAYR. Europ. Formicid., p. 52. 1861.
Type: *Prenolepis imparis* Say (designated by Emery, 1906).[3]
Prionogenys EMERY. Ann. Soc. Ent. Belg., XXXIX, p. 348. 1895.
Type: *Prionogenys podenzanai* Emery (monobasic).
Prionomyrmex MAYR. Beitr. Naturk. Preuss., I, p. 77. 1868.
Type: *Prionomyrmex longiceps* Mayr (monobasic).
Prionopelta MAYR. Sitzb. Akad. Wiss. Wien, LIII, p. 503. 1866.
Type: *Prionopelta punctulata* Mayr (monobasic).
Pristomyrmex MAYR. Verh. zool. bot.. Ges. Wien, XVI, p. 903. 1866.
Type: *Pristomyrmex pungens* Mayr (monobasic).
Probolomyrmex MAYR. Ann. K. K. Naturhist. Hofmus. Wien, XVI, p. 2. 1901.
Type: *Probolomyrmex filiformis* Mayr (monobasic).
Proceratium ROGER. Berlin. Ent. Zeitschr., VII, p. 171. 1863.
Type: *Proceratium silaceum* Roger (monobasic).
Procryptocerus EMERY. Ann. Mus. Civ. Stor. Nat. Genova, XXV, p. 470 *nota*. 1887.
Type: *Meranoplus striatus* F. Smith (by present designation).
Proformica RUZSKY. Horæ Soc. Ent. Ross., XXXVI, p. 303. 1903. (Subgenus of *Formica*.)
Type: *Formica nasuta* Nylander (by present designation).
Prolasius FOREL. Mittheil. Schweiz. Ent. Ges., VIII, p. 332. 1892. (Subgenus of *Melophorus*.)
Type: *Formica advena* F. Smith (monobasic).
Propodomyrma WHEELER. Ants, their Struct. Devel. & Behav., p. 163. 1910.
Type: *Propodomyrma samlandica* Wheeler (monobasic).
Psalidomyrmex ERN. ANDRÉ. Rev. d'Ent., VIII, p. 313. 1890.
Type: *Psalidomyrmex foveolatus* Ern. André (monobasic).
Pseudodichthadia ERN. ANDRÉ. Suppl. Spéc. Formic. d'Europ., p. 6. 1885. (= *Labidus*.)
Type: *Pseudodichthadia incerta* Ern. André = female *Formica cæca* Latreille (monobasic).
Pseudolasius EMERY. Ann. Mus. Civ. Stor. Nat. Genov., XXIV, p. 244. 1886.
Type: *Formica familiaris* F. Smith (designated by Bingham, 1903).
Pseudomyrma LUND. Ann. Sci. Nat., XXIII, p. 137. 1831.
Type: *Formica gracilis* Fabricius.
Pseudoponera EMERY. Ann. Soc. Ent. Belg., XLV. p. 42. 1901. (Subgenus of *Euponera*.)
Type: *Ponera amblyops* Emery (designated by Emery, 1901).
Pyramica ROGER. Berlin. Ent. Zeitschr., VI, p. 251. 1862. (= *Strumigenys*.)
Type: *Pyramica gundlachi* Roger; worker only (monobasic).
Rhinomyrmex FOREL. Ann. Soc. Ent. Belg., XXX, p. 192. 1886.
Type: *Rhinomyrmex klœsi* Forel (monobasic).

[3] Bingham (1903) had previously designated *P. nitens* Mayr as the type, but this is merely a European form of *P. imparis*.

Rhizomyrma Forel. Trans. Ent. Soc. London, IV, p. 347. 1893. (Subgenus of *Acropyga*.)

Type: *Acropyga* (*Rhizomyrma*) *goeldii* Forel (by present designation).

Rhogmus Shuckard. Ann. Mag. Nat. Hist., V, p. 323. 1840. (Subgenus of *Dorylus*.)

Type: *Rhogmus fimbriatus* Shuckard (designated by Shuckard, 1840).

Rhopalomastix Forel. Ann. Soc. Ent. Belg., XLIV, p. 24. 1900.

Type: *Rhopalomastix rothneyi* Forel (monobasic).

Rhopalomyrmex Mayr. Beitr. Naturk. Preuss., I, p. 41. 1868.

Type: *Rhopalomyrmex pygmæus* Mayr (monobasic).

Rhopalopone Emery. Ann. Mus. Civ. Stor. Nat. Genova, (2) XVIII, p. 549 1897.

Type: *Rhopalopone epinotalis* Emery (monobasic).

Rhopalothrix Mayr. Sitzb. Akad. Wiss. Wien, LXI, p. 415. 1870.

Type: *Rhopalothrix ciliata* Mayr (first species by present designation).

Rhoptromyrmex Mayr. Ann. K. K. Naturhist. Hofmus. Wien, XVI, p. 18. 1901.

Type: *Rhoptromyrmex globulinodis* Mayr (first of two species by present designation).

Rhytidoponera Mayr. Verh. zool. bot. Ges. Wien, XII, p. 731. 1862. (Subgenus of *Ectatomma*.)

Type: *Ectatomma* (*Rhytidoponera*) *metallicum* F. Smith (by present designation).

Rogeria Emery. Bull. Soc. Ent. Ital., XXVI, p. 52. 1894.

Type: *Rogeria curvipubens* Emery (second of three species by present designation).

Semonius Forel. Schultze, Zool. Anthrop. Ergeb. Forsch. West. u. Zent. Südafrika, IV, p. 21. 1910.

Type: *Semonius schultzei* Forel (monobasic).

Sericomyrmex Mayr. Novara Reise Formicid., p. 83. 1865.

Type: *Sericomyrmex opacus* Mayr (monobasic).

Shuckardia Emery. Zool. Jahrb. Abth. f. Syst., VIII, p. 703. 1895. (= *Alaopone*.)

Type: *Dorylus atriceps* Shuckard — *D. abeillei* Ern. André (designated by Emery, 1895).

Sifolinia Emery. Rend. R. Accad. Sci. Ist. Bologna, p. 49. 1907.

Type: *Sifolinia lauræ* Emery (monobasic).

Sima Roger. Berlin. Ent. Zeitschr., VII, p. 178. 1863.

Type: *Pseudomyrma ? allaborans* Walker (designated by Bingham, 1903).

Simopone Forel. Grandidier's Hist. Madagascar, XX, p. 247. 1891.

Type: *Simopone grandidieri* Forel (first species by present designation).

Solenopsis Westwood. Ann. Mag. Nat. Hist., VI, p. 86. 1841.

Type: *Solenopsis mandibularis* Westwood = *Atta geminata* Fabricius (monobasic).

Spalacomyrmex Emery. Ann. Mus. Civ. Stor. Nat. Genova, (2) VII, p. 489. 1889. (= *Centromyrmex*.)

Type: *Spalacomyrmex feæ* Emery (monobasic).

Sphegomyrmex Imhoff. Verh. Naturf. Ges. Basel., X, p. 175. 1852. (= *Anomma*.)

Type: *Dorylus nigricans* Fabricius (monobasic).

Sphinctomyrmex Mayr. Verh. zool. bot. Ges. Wien, XVI, p. 895. 1866.
Type: *Sphinctomyrmex stali* Mayr (monobasic).
Stenamma Westwood. Introd. Mod. Classif. Ins., II, Synops., p. 83. 1840.
Type: *Stenamma westwoodi* (Stephens) Westwood (monobasic).
Stenomyrmex Mayr. Verh. zool. bot. Ges. Wien, XII, p. 711. 1862. (Subgenus of *Anochetus*.)
Type: *Myrmecia emarginata* Fabricius (first of two species by present designation).
Stereomyrmex Emery. Deutsch. Ent. Zeitschr., p. 115. 1899.
Type: *Stereomyrmex horni* Emery (monobasic).
Stictoponera Mayr. Verh. zool. bot. Ges. Wien, XXXVII, p. 539. 1887. (Subgenus of *Ectatomma*.)
Type: *Ectatomma coxale* Roger (by present designation).
Stigmacros Forel. Ann. Soc. Ent. Belg., XLIX, p. 179. 1905. *Nom. nov.* for **Acrostigma** Forel (*nec* Emery), *nom. præocc.* (Subgenus of *Acantholepis*.)
Type: *Acantholepis (Acrostigma) froggatti* Forel (first of four species by present designation).
Stigmatomma Roger. Berlin. Ent. Zeitschr., III, p. 250. 1859.
Type: *Stigmatomma denticulatum* Roger (first of two species, designated by Bingham, 1903).
Stigmomyrmex Mayr. Beitr. Naturk. Preuss., I, p. 95. 1868.
Type: *Stigmomyrmex venustus* Mayr (by present designation).
Streblognathus Mayr. Verh. zool. bot. Ges. Wien, XII, p. 716. 1862.
Type: *Ponera æthiopica* F. Smith (monobasic).
Strongylognathus Mayr. Verh. zool. bot. Ver. Wien, III, p. 389. 1853.
Type: *Eciton ? testaceum* Schenck (monobasic).
Strumigenys F. Smith. Journ. Ent., I, p. 71. 1860.
Type: *Strumigenys mandibularis* F. Smith (monobasic).
Symmyrmica Wheeler. Bull. Amer. Mus. Nat. Hist., XX, p. 3. 1904.
Type: *Symmyrmica chamberlini* Wheeler (monobasic).
Sympheidole Wheeler. Bull. Amer. Mus. Nat. Hist., XX, p. 7. 1904.
Type: *Sympheidole elecebra* Wheeler (monobasic).
Syscia Roger. Berlin. Ent. Zeitschr., V, p. 19. 1861. (Subgenus of *Cerapachys*.)
Type: *Syscia typhla* Roger (monobasic).
Sysphincta Roger. Berlin. Ent. Zeitschr., VII, p. 175. 1863.
Type: *Sysphincta micrommata* Roger (monobasic).
Tapinoma Förster. Hymenopt. Stud., I, p. 43. 1850.
Type: *Formica erratica* Latreille (monobasic).
Technomyrmex Mayr. Ann. Mus. Civ. Stor. Nat. Genova, II, p. 147. 1870.
Type: *Technomyrmex strenuus* Mayr (designated by Bingham, 1903).
Temnothorax Mayr. Europ. Formic., p. 68. 1861. (Subgenus of *Leptothorax*.)
Type: *Temnothorax recedens* Mayr (monobasic).
Tetramorium Mayr. Verh. zool. bot. Ver. Wien, V, p. 423. 1855.
Type: *Formica cæspitum* Linné (designated by Bingham, 1903).
Tetraponera F. Smith. Ann. Mag. Nat. Hist. (2) IX, p. 44. 1852. (= *Sima*.)
Type: *Tetraponera atrata* F. Smith = *Eciton nigrum* Jerdon = *Sima nigra* Emery (by present designation).

Tetrogmus ROGER. Berlin. Ent. Zeitschr., I, p. 10. 1857. (Subgenus of *Tetramorium*.)
Type: *Tetrogmus caldarius* Roger = *Myrmica simillima* (Nylander) F. Smith (monobasic).

Thaumatomyrmex MAYR. Verh. zool. bot. Ges. Wien, XXXVII, p. 531. 1887.
Type: *Thaumatomyrmex mutilatus* Mayr (monobasic).

Tomognathus MAYR. Europ. Formic., p. 56. 1861. (=*Harpagoxenus*.)
Type: *Myrmica sublævis* Nylander (monobasic).

Trachymyrmex FOREL. Ann. Soc. Ent. Belg., XXXVII, p. 600. 1893. (Subgenus of *Atta*.)
Type: *Atta septentrionalis* McCook (by present designation).

Tranopelta MAYR. Sitzb. Akad. Wiss. Wien, LIII, p. 514. 1866.
Type: *Tranopelta gilva* Mayr (monobasic).

Trapeziopelta MAYR. Verh. zool. bot. Ges. Wien, XII, p. 715. 1862.
Type: *Ponera maligna* F. Smith (monobasic).

Trichomyrmex MAYR. Novara Reise Formicid., p. 19. 1865.
Type: *Trichomyrmex rogeri* Mayr (monobasic).

Trichoscapa EMERY. Ann. Accad. Nat. Napoli, (2) II, p. 24. 1869. (=*Strumigenys*.)
Type: *Trichoscapa membranifera* Emery (monobasic).

Triglyphothrix FOREL. C. R. Soc. Ent. Belg., p. CVI. 1890.
Type: *Triglyphothrix walshi* Forel (monobasic).

Trigonogaster FOREL. C. R. Soc. Ent. Belg., p. CIX. 1890.
Type: *Triglyphothrix walshi* Forel (monobasic).

Turneria FOREL. Ann. Soc. Ent. Belg., XXXIX, p. 419. 1895.
Type: *Turneria bidentata* Forel (monobasic).

Typhlatta F. SMITH. Journ. Proc. Linn. Soc. Lond., II, p. 79. 1857. (=*Ænictus*.)
Type: *Typhlatta læviceps* F. Smith (monobasic).

Typhlomyrmex GISTEL. Myster. Europ. Insectenwelt, p. 417. 1856.
Type: *Myrmica typhlops* (*nomen nudum*).

Typhlomyrmex MAYR. Verh. zool. bot. Ges. Wien, XII, p. 736. 1862.
Type: *Typhlomyrmex rogenhoferi* Mayr (monobasic).

Typhlopone WESTWOOD. Introd. Mod. Classif. Ins., II, p. 219. 1840. (Subgenus of *Dorylus*.)
Type: *Typhlopone fulva* Westwood (designated by Emery, 1895).

Vollenhovia MAYR. Novara Reise Formicid., p. 21. 1865.
Type: *Vollenhovia punctatostriata* Mayr (monobasic).

Wasmannia FOREL. Trans. Ent. Soc. London, IV, p. 383. 1893.
Type: *Tetramorium auropunctatum* Roger (first of two species by present designation).

Wheeleria FOREL. Ann. Soc. Ent. Belg., XLIX, p. 171. 1905. (=*Wheeleriella*.)
Type: *Wheeleria santschii* Forel (monobasic).

Wheeleriella FOREL. Intern. Sc. Rev., IV, p. 145. 1907. *Nom. nov.* for *Wheeleria*, *nom. præocc.*
Type: *Wheeleria santschii* Forel (monobasic).

Xenomyrmex FOREL. Bull. Soc. Vaud. Sci. Nat., (2) XX, p. 369. 1884.
Type: *Xenomyrmex stolli* Forel (monobasic).

Xiphomyrmex Forel. Mitthell. Schweiz. Ent. Ges., VII, p. 385. 1887. (Subgenus of *Tetramorium*.)

Type: *Tetramorium* (*Xiphomyrmex*) *kelleri* Forel (by present designation).

Zacryptocerus Ashmead. Canad. Ent., XXXVII, p. 384. 1905. (=*Cryptocerus*.)

Type: *Cryptocerus multistrigus* F. Smith (designated by Ashmead, but no such species exists).[4]

[4] I believe this name must be a clerical error for *C. clypeatus* Fabr., as Ashmead some years ago gave me a specimen of this ant labeled "Zacryptocerus."

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THE HISTORY OF THE AMERICAN RACE.[1]

BY FRANZ BOAS.

LADIES AND GENTLEMEN:—The custom which demands that your President address you at the time of the annual meeting—not when the Academy is in formal session, but when seated around the hospitable board—lays upon him a difficult duty. You expect from him the best that he can give in his science; and still what he gives should be appropriate to the hour, when in pleasant personal intercourse thoughts find expression as they arise, and the stimulated imagination carries us away to more daring flights than those we venture on when our thoughts are given to serious work. Permit me, therefore, to join in the imaginative mood and to lay aside the scruples and doubts of the study and to tell you how in my dreams the stones that we are shaping with arduous labor, and that may in time form a solid structure, but none of which is finished as yet, seem to fit together; and let me sketch before your eyes the airy picture of a history of the American race as it appears before me in dim outlines.

Man had arisen from his animal ancestors. His upright posture, his large brain, the beginnings of articulate and organized language and the use of tools marked the contrast between him and animals. Already a differentiation of human types had set in. From an unknown ancestral type, that may have been related to the Australoid type, two fundamentally distinct forms had developed—the Negroid type and the Mongoloid type. The former spread all around the Indian Ocean; the latter found his habitat in northern and central Asia, and also reached Europe and the New World. The uniformity of these types ceased with their wide spread over the continents, and the isolation of small communities. Bushmen, Negroes and Papuans mark some divergent developments of the one type; Americans, East Asiatics and Malays, some of the other. The development of varieties in each group showed similarities in all regions where the type occurred. The races located on both sides of the Pacific Ocean exhibited the tendency to loss of pigmentation of skin, eyes and hair; to a strong development of the nose, and to a reduction of the

[1] Address of the retiring President, read at the annual meeting of the Academy, 18 December, 1911.

size of the face. Thus types like the Europeans, the Ainu of Japan and some Indian tribes of the Pacific coast exhibit certain striking similarities in form. This tendency to parallel modification of the type indicates early relationship.

After these conditions had developed, one of the last ice ages set in. The members of the race that lived in America were cut off from their congeners in the Old World, and during a long period of isolation an independent development of types occurred. Still the time was not long enough to wipe out the family resemblance between the Asiatics and Americans, which persists up to this day; but numerous new lines of growth developed. The face assumed a distinct form, principally through the increase of size of the nose and of the cheek-bones. The wide spread of the race over the whole territory of the two Americas that was free of ice, and the isolation and small number of individuals in each community, gave rise to long-continued inbreeding, and, with it, to a sharp individualization of local types. This was emphasized by the subtle influences of natural and social environment. With the slow increase in numbers, these types came into contact; and through mixture and migration a new distribution of typical forms developed. Thus the American race came to represent the picture of a rather irregular distribution of distinct types and colors, spread over the whole continent. The color of the skin varied from light to almost chocolate brown; the form of the head, from rounded to elongated; the form of the face, from very wide to rather narrow; the color of the hair, from black to dark brown and even blond, its form from straight to wavy; the lips were on the whole moderately full; the nose varied from the eagle nose of the Mississippi Indian to the concave nose of some South Americans and northwest Americans. Notwithstanding the wider distribution of these types, each area presented a fairly homogeneous picture.

Gradually the great ice-cap retired. Communication between America and Asia became possible, while Europe was cut off by the wide expanse of the Atlantic Ocean. Man followed the ice-cap northward. Members of the American race crossed over to Asiatic soil and occupied parts of Siberia, where finally they came into contact with the Asiatic group, which had also spread northward with the retreat of the ice.

Even at this early time, when the tribes were small in number and weak, human migration was only halted by impassable barriers; and thus contact of members of one group with those of another was not rare, and was always accompanied by the exchange of inventions and other cultural possessions.

We must revert once more to the earlier period, when man first entered

our continent. The step from animal to man had long been made. Man brought with him a language, the use of fire, the art of making fire, the use of tools for breaking and cutting and his companionship with the dog. No other animal had yet become the associate of man. Whether he was acquainted with the bow and arrow, the lance and other more complex tools, is very doubtful.

What the languages of the earliest Americans may have been we cannot tell. There is no reason to believe that there was only one language, for the slow infiltration of scattered communities may have brought groups possessing entirely different forms of linguistic expression into the continent. Certain it is, that, when man began to increase in numbers, the number of languages spoken were legion. Complexity of form characterized all of them. Sprung from the same root, some became so much differentiated, that their genetic relationship can hardly be recognized. By mutual influences, the articulations of some were so changed as to agree with those of their neighbors. Forms of thought as expressed in one language influenced others, and thus heterogeneous elements were cast in similar forms. As the race increased in numbers, some tribes became more powerful than others, and in intertribal wars many communities were exterminated. With them died their languages and sometimes also their type, although it is likely that in most cases these persist in the descendants of captured women. Thus a gradual elimination of the older stocks occurred, which were replaced by newer dialects of a few groups in which, for this reason, genetic relationship can still easily be traced. Only in those regions where no tribe gained the ascendancy does the old multiplicity of stocks persist. Hence the confusion of languages in California, in many parts of Central and South America, and the comparative homogeneity on the Great Plains, on the plateau of Mexico, and in eastern South America. The diversity of sound and grammatical form which pertains to the old stocks is so great that it is hardly possible to find one feature that is common to the languages of America and that does not belong also to other continents. Certainly all the most prominent characteristics of many American languages are found to the same extent among the tribes of Siberia.

When the contact between Asia and America was re-established, the culture of the whole continent was very simple. Some new inventions had been added to the old stock; weapons had been perfected; the beginnings of decorative art had been laid, and the ideas of the race had advanced in many directions. At this period, the Central Americans made the important step from the gathering of roots, berries and grains to the permanent cultivation of plants near their homes. The development

of the cultivated Indian-corn occurred. With it the food-supply of the people became more stable, and the population increased at a much more rapid rate than before. Other plants, like the bean, were taken into cultivation; and the more certain the food-supply, the more rapid became the increase in population. The process that began in the Old World with the cultivation of millet and other grains was paralleled here; and step by step the new art spread over new territories, until it had reached the area now occupied by the Argentine Republic in the south, and the Great Lakes in the north. Only the extreme south of South America and the extreme north and northwest of this continent remained outside of this zone, partly due to climatic reasons, partly due to their remote geographical position.

The cultivation of plants and the concurrent increase in population revolutionized the ethnological conditions of the continent; for, owing to their large numbers, the agricultural people also gained the ascendancy over others who did not conform to their habits and remained fewer in numbers.

About this time, perhaps even before the perfected cultivation of plants, a marvelous industrial development set in. Basketry, pottery and weaving were some of the important industries that originated in this period. It is not likely that their origin can be traced in the same way to one restricted area, as in the case of the cultivation of Indian corn, but the many beginnings were more or less moulded in one form, and cultural stimuli probably flowed in many different directions, giving rise to technical forms that, notwithstanding their great diversity, bear the impress of one continental development. Nothing shows this process of assimilation more impressively than the decorative art of the continent. Forms exuberantly developed in Mexico or western South America recur in simpler form in the United States and in the Argentine Republic—not identical, to be sure, but still betraying their family resemblance. The marginal people of the continent alone have learned nothing of these arts. Pottery reached neither the Pacific Northwest nor the extreme south of South America, and the art forms of the North Pacific coast and of the Arctic coast show no affiliation with those of the middle portions of the continent. These districts remained almost excluded from the general flow of American culture, as it developed in the agricultural areas of the middle parts of the two Americas. Here we may perhaps still find something similar to what existed in our continent before the period of rapid cultural advance set in.

The religious life of the race grew with its other cultural achievements. A strong ceremonialism pervaded the whole life and attained its

culminating point in the most complex and populous communities. The fundamental ideas were disseminated from tribe to tribe and found an echo wherever they reached. Thus from many distinct beginnings grew up a peculiar type of ritualism that preserves a similar character almost wherever it exists at all. The thinkers among all these tribes were moved by one fundamental set of ideas, and hence all developed on somewhat similar lines; but the harder the conditions of life, the less is the number of independent thinkers, and the diversity and individuality of tribal ritualism decrease, therefore, as the agricultural resources of the tribes dwindle. In the extreme Northwest and South, only weak traces of the modern middle American ceremonialism are to be found.

Thus presents itself to our minds the picture of American civilization developing in the favored middle parts of the continents and spreading by a continuous flowing to and fro of ideas and inventions which stimulated continued growth. In contrast to these, the marginal areas of the extreme South and of the North and Northwest remained in a more stable condition.

Neither history nor archæology nor ethnology allows us at present to follow this complex development in any detail. On the contrary, there seem to be yawning gaps between the various centers that sometimes seem as though they could not be bridged; and still the conviction grows stronger and stronger that this whole culture represents as much an inner unity as that of the Old World.

Somewhat aside from the general current stands eastern South America, which, although not uninfluenced by the stream of Western culture, followed in a halting way only, and in many respects went its own way. The isolation of the dense forests, the smallness of the tribes and their position aside from the great current of events that had their seat in the plateaus of the West may have contributed to this condition of affairs. Sufficient vigor, however, existed here to allow an energetic expansion northward, which built a cultural bridge between the Atlantic slopes of North and South America that brought about a certain degree of individualization of the East as compared to the West.

I will not follow the higher civilizations that were built up on the basis of the Western culture in Mexico, Yucatan and on the western plateaus of South America. When these civilizations arose, their foundations were probably those that I described before as pertaining to a large portion of middle America, extending from some parts of the United States well south into South America. On this basis, however, they built up a promising structure: they laid the foundation of the sciences, developed the art of writing, learned how to work precious metals and copper

and advanced in the arts of architecture and engineering. When the advent of the Spaniards cut short this growth, it had attained a stage that might easily have led to accelerated advances.

We must now turn to the northern marginal area, which did not take part to any considerable extent in the cultural work of the people of middle America. Notwithstanding this, the area was not isolated but received stimuli from another direction. The Old World lies near at hand, and from here flowed the sources of new cultural achievements.

As in the New World, the early growth of culture in Central America had stimulated the neighboring tribes, and as inventions and ideas had been carried to and fro, so it happened in the Old World. A constant exchange of cultural achievements may be observed from the coasts of the Mediterranean Sea to China and Japan. What wonder, then, if the waves of this movement struck the shores of our world where it is nearest Asia, not with a strong impact but as the last ripples of the spreading circle. The Siberians and Americans were closely affiliated before the introduction of domesticated animals gave a new character to Siberian life; and at this time the Asiatic house, bow, armor and Asiatic tales found their way to America and spread over the whole northwestern portion of the North American continent, reaching even the tribes of our Western prairies.

The Southern marginal area, the extreme south of South America and parts of Brazil present a different set of conditions—an isolation that is probably equalled in no other part of the world excepting, perhaps, Tasmania. Unfortunately, our knowledge of these regions is so imperfect that almost nothing can be said in regard to the type of culture of the tribes inhabiting this area. May I point out that here lies the most important problem for the investigation of the earliest ethnic history of the American Continent, because here alone may we hope to recover remains of the earliest types of American mental development? The investigation of this problem, of the ethnology of the Fuegians and Ghes tribes according to modern thorough methods, may therefore urgently be recommended to the Carnegie Institution, that furthers so many lines of research, or to other institutions that are devoted to the advancement of knowledge.

Here halts my fancy, which has taken me in rapid flight over thousands of years, over endless changes of types and peoples. I do not venture to speculate about the question of a cultural relation between the islands of Polynesia and South America; for the suggestions are too slight, and the improbability of relations seems at present too great.

We may, however, cast a glance at the forms that America presents when compared to the Old World If our picture contains any truth, the independence of American achievements from Old World achievements stands out prominently. The industrial arts were discovered in two large areas independently--the Afro-Asiatic and the American. They spread over continents but remained separated until the period of European colonization. To a great extent, the discoveries made were analogous—basketry, weaving, pottery, work in metals, agriculture. The important step that the Asiatic or European hunter made to the domestication of animals had hardly begun in America, where the Peruvians had developed the use of the llama. Much less had the still more far-reaching discovery been made of agriculture with the help of animals and the invention of the wheel. The use of smelted iron for tools was not known. Important differences may also be traced in fundamental forms of social institutions, arts and religious beliefs. Thus some of the most important advances of the races of the Old World were not known in America, although in other respects the work of civilization had far advanced.

In concluding, I beg to remind you once more that the sketch that I have given, although based on the accumulation of observed data, must not be taken as more than a lightly woven fabric of hypothesis. At every step, there are lacunæ of our knowledge which our imagination may temporarily bridge to serve as a guide for further inquiries but which have to be filled by solid, careful work to reach results that will be acceptable before the forum of science.

[ANNALS NEW YORK ACADEMY OF SCIENCES, Vol. XXI, pp. 185-252.
25 March, 1912.]

RECORD OF MEETINGS

OF THE

NEW YORK ACADEMY OF SCIENCES.

January, 1911, to December, 1911.

BY EDMUND OTIS HOVEY, *Recording Secretary.*

BUSINESS MEETING.

9 JANUARY, 1911.

The Academy met at 8:15 P. M. at the American Museum of Natural History, Vice-President Kunz presiding in the absence of President Boas.

The minutes of the last business meeting were read and approved.

The following candidates for active membership in the Academy, recommended by Council, were duly elected:

John P. Haines, 20 Fifth Avenue,
Daniel O. Fearing, Newport, R. I.,
A. O. Garrett, 615 South 9th St., Long Island City,
C. W. Parsons, 30 West 95th Street.

The Recording Secretary announced that Dr. C. B. Davenport had declined to accept the election to Vice-President for 1911, and Dr. F. A. Lucas had been elected Vice-President of the Academy and Chairman of the Section of Biology to take his place. He reported further that Dr. Clark Wissler had been elected Councilor for one year in place of Dr. Franz Boas and that Professor C. C. Trowbridge had been elected Councilor for three years in place of Dr. Simon Flexner.

The Academy then adjourned.

EDMUND OTIS HOVEY,
Recording Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

9 January, 1911.

Section was called to order at 8:25 P. M., Vice-President George F. Kunz presiding. About 150 members and visitors were present.

The reading of the minutes was dispensed with, and there being no special business requiring immediate attention, the meeting was at once turned over to the following lecturer:

Frank D. Adams, Results of Experiments on the Behavior of Rocks under Pressure.

The Chairman introduced Professor Adams, Dean of Applied Science and Professor of Geology in McGill University and a corresponding member of the Academy, who gave a brief résumé of earlier work and explained the objects sought and difficulties encountered and a most interesting and instructive account of the methods and results of his own experiments. At the close of the lecture, Mr. Chambers asked whether any experiments had been made in the presence of water. Professor Adams replied that only one sample had been tested in this manner.

The Academy tendered a vote of thanks to Professor Adams for his lecture.

The meeting then adjourned.

Charles P. Berkey,
Secretary.

SECTION OF BIOLOGY.

16 January, 1911.

Section met at 8:15 P. M., Vice-President Frederic A. Lucas presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

C. Stuart Gager, Cryptomeric Inheritance in Onagra.
Roy C. Andrews, Field Notes on Japanese Whales.

Summary of Papers.

Dr. **Gager** made reference to an abnormal plant of *Onagra biennis* that appeared in a pedigreed culture following exposure to radium rays of the ovule employed in producing the plant. The plant possessed two primary shoot-systems (rosettes and subsequent cauline stems) of equivalent value but manifesting entirely unlike morphological characters.

Photographs were shown, and various possibilities were suggested as to the cause or causes of the anomaly. That the effect was due to the exposure to radium rays was held to be possible, though not conclusively shown. The antecedent history of the plant and the fact that hybrids between the two unlike halves manifested, in the F_1 and F_2 generations, the characters of only one of the parent shoots, was interpreted to emphasize the fact, already recognized, that the inheritance of a character and its expression are two quite different phenomena.

Mr. **Andrews** gave an account of a recent seven-months' stay at the Japanese whaling stations, telling of the methods employed in capturing and preparing the whales for commercial use; also of new notes on the habits of finback, blue and sei whales. The latter species, called by the Japanese "sardine whale," is referable to *Balænoptera arctica* Schlegel, and although it has been taken for a number of years at the Japanese stations, almost no material relating to it is extant. The species is so closely allied to *Balænoptera borealis* Lesson of the Atlantic that further investigation will probably prove it synonymous. Photographs of the rare North Pacific blackfish (*Globicephalus scammoni*) and of several species of dolphins were also shown. It was announced that a new porpoise of a most peculiar body shape had been secured and would be described in a future number of the American Museum Bulletin. The paper was illustrated with lantern slides.

The Section then adjourned.

L. Hussakof,
Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

23 January, 1911.

Section met at 8:15 P. M., Vice-President Campbell presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

Clifford B. Harmon, Experiments in Aviation.

Hudson Maxim, Practical Utility of Flying Machines.

Philip Wilcox, The Aëroplane.

James H. Hare, Taking the First Photographs of the Flights of the Wright Brothers at Kitty Hawk, North Carolina.

SUMMARY OF PAPERS.

The various papers were well illustrated with lantern slides and by models loaned by the United States Aëronautical Reserve.

The Section then adjourned.

EDWARD J. THATCHER,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

30 JANUARY, 1911.

Section met at 8:15 P. M., Gen. James Grant Wilson presiding.
The minutes of the last meeting of the Section were read and approved.
The following programme was then offered:

Pliny E. Goddard, THE DISTRIBUTION AND RELATIONSHIP OF THE APACHE.

SUMMARY OF PAPER.

Dr. **Goddard** emphasized the fact that the Apache are divided into a number of distinct political and dialectic groups; while culturally, there is a gradual transition as an observer proceeds from east to west from the life of the buffalo-hunting Plains type into that of the Southwestern culture as represented by the Pima.

The Section then adjourned.

F. LYMAN WELLS,
Secretary.

BUSINESS MEETING.

6 FEBRUARY, 1911.

The Academy met at 8:20 P. M. at the American Museum of Natural History, Vice-President Kunz presiding in the absence of President Boas.
The minutes of the last business meeting were read and approved.
The following candidates for membership in the Academy, recommended by Council, were duly elected:

ACTIVE MEMBERSHIP.

Herbert Lang, American Museum of Natural History.

ASSOCIATE MEMBERSHIP.

C. T. Kirk, Normal College,
Miss Evangeline Moon, Normal College.

The Recording Secretary then reported the following deaths:

Sir Francis Galton, an Honorary Member for 1 year,
Hon. J. Hampden Robb, an Active Member for 13 years,
J. J. Higginson, an Honorary Member for 5 years.

The Academy then adjourned.

EDMUND OTIS HOVEY,
Recording Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

6 FEBRUARY, 1911.

Section was called to order at 8:25 P. M. Vice-President Kunz presiding. About 60 members and others were in attendance.

The minutes of the previous meeting were read and approved.

A communication was presented from Prof. D. S. Martin on the naming of two mineral varieties. The first is a variety of muscovite, for which the name Schernikite is proposed. The other is a variety of mesolite, for which the name Winchellite is suggested.

The following titles were presented:

A. A. Julien, THE EVIDENCE FROM THE PALISADES ON THE GENESIS OF ANTIGORITE (By title).

G. S. Rogers, GEOLOGY OF THE CORTLANDT SERIES AND ITS EMERY DEPOSITS (By title).

SUMMARY OF PAPER.

Dr. **Martin**, in his paper, said: At the meeting of the New York Mineralogical Club, held at the American Museum of Natural History on December 14th, 1910, I exhibited certain minerals and proposed therefor two varietal names as follows:

(1) The fibro-prismatic pink variety of muscovite, identified as such in composition by Bowman in the Mineralogical Magazine in 1902 but so remarkably different in its physical characters and entire "habit" that it is certainly deserving of a varietal name. The mineral occurs freely and almost exclusively at Haddam Rock, Conn., intergrown with ordinary muscovite and lepidolite, in the albitic dyke. As the specimens described and identified by Bowman formed a part of a series of Haddam Rock minerals presented to Oxford University by a member and ex-president

of the Mineralogical Club, Mr. Ernest Schernikow, of this city, I propose for this marked and peculiar variety the name of Schernikite.

(2) The nodular variety of mesolite, generally called Thomsonite, from Grand Marais, Lake Superior. Professor N. H. Winchell, in several articles, has shown this mineral to be not Thomsonite at all but a true mesolite in composition and has urged the use of the latter correct name instead of the former incorrect one. As it is, however, a distinct variety peculiar to that locality and considerably used as a "local" gem-stone, it is entitled to a name as much as lintonite or chlorastrolite, and in recognition of its identifier, I suggest that of Winchellite.

The evening was then given to the following lecture:

Frank A. Perrett, K. I. C., THE 1909 ERUPTION AT TENERIFF AND THE GREAT ERUPTION OF ETNA IN MARCH AND APRIL, 1910.

Mr. Perrett has been for several years a close student of volcanic phenomena. Many excellent lantern illustrations were shown representing recent activities and conditions investigated by Mr. Perrett. The lecture was listened to with great interest, and remarks were made by several members of the Academy.

The meeting then adjourned.

CHARLES P. BERKEY,
Secretary.

SECTION OF BIOLOGY.

13 FEBRUARY, 1911.

Section met at 8:15 P. M., Vice-President Frederic A. Lucas presiding.
The minutes of the last meeting of the Section were read and approved.
The following programme was then offered:

W. D. Matthew, CLIMATE AND EVOLUTION.

W. K. Gregory, ON THE LIMBS OF *Eryops* AND THE ORIGIN OF LIMBS FROM PAIRED FINS.

SUMMARY OF PAPERS.

Dr. **Matthew** said in abstract: The thesis of the paper is as follows:

1. Secular climatic change has been an important factor in the evolution of land vertebrates and the principal known cause of their present distribution.

2. The principal lines of migration in later geological epochs have been radial from holarctic centers of dispersal.

3. The geographic changes required to explain the past and present distribution of land vertebrates are not extensive and do not affect the permanence of the ocean basins as defined by the continental shelf.

4. The theory of alternations of moist and uniform with arid and zonal climates associated, respectively, with partial submergence and extreme emergence of the continental areas, as elaborated by Chamberlin, are in exact accord with the apparent course of evolution of land vertebrates, when interpreted with due allowance for the probable gaps in the geologic record.

5. The numerous hypothetic land bridges in temperate, tropical and southern regions, connecting continents now separated by deep oceans, which have been advocated by various authors, are improbable, inconsistent and unnecessary to explain geographic distribution. On the contrary, the known facts point distinctly to the permanency of the deep-ocean basins during the later epochs of geologic time, to the alternate connection and separation of the land areas within the line of the continental shelf and to the continued isolation of those land areas which are surrounded by deep ocean.

These theories are substantially an adaptation of the conservative views of Wallace and other zoölogists to the geological theories of Chamberlin. They are defended by a consideration (1) of the nature and extent of the defects in the geological record; (2) of the relations of the zoölogical regions to each other and the changes effected by elevation or submergence of 100 fathoms; (3) of the principles of dispersal of land animals; (4) of the character of the fauna of oceanic islands (including Madagascar, Cuba and New Zealand) and the degree of probability which attaches to accidental transportation as a means of populating them; (5) of the present and known past distribution of the mammalia, group by group, in considerable detail; (6) of the distribution of the different orders of reptilia in a less detailed manner; (7) of the distribution of birds and fishes, with a few instances from invertebrate distribution which have been especially urged in support of hypothetical bridges; (8) of the objections to such bridges and an interpretation of the real significance of such evidence as has been adduced in support of them.

I believe that the supposed cumulative evidence obtained in various groups of animals or plants for various continental bridges is due simply to identical errors in interpretation running through all such instances. On the other hand, to admit such bridges would seem to involve certain distribution results, which, in the groups which I have studied, assuredly do not exist.

Dr. **Gregory** said in abstract: In a skeleton of the temnospondylous amphibian, *Eryops megacephalus* Cope, from the Permian of Texas, which is now being mounted in the American Museum, the limbs are of special interest. Many resemblances to the contemporary reptile *Diadectes* are seen: in the stout, long coraco-scapula, the short, wide-headed humerus, with its very wide, prominent and backwardly directed entocondyle, in the short fore-arm, in the very heavy, solid pelvis, stout femur and fully ossified carpus and tarsus. In the character of its limbs, *Eryops* was on the whole nearer to *Sphenodon* than to the Urodeles, though far more archaic than the former. As shown by the facets, the humerus and femur were held almost at right angles to the body, the opposite feet being held very widely apart.

The generalized character of the limbs of *Eryops* with respect to those of higher Tetrapoda invite renewed inquiry into the origin of paired limbs from fins. The limbs of known branchiosaurs and microsaurs do not carry us very far back toward any known type of fish fin. In these orders, the cylindrical shafts of the long bones, with cartilaginous ends, the cartilaginous carpus and tarsus, the weak shoulder girdle and pelvis suggest a secondary adaptation to aquatic habits.

From the work of Thacher, Goodrich, Dean, R. C. Osburn and others, it seems probable that the paired fins of fishes, like the median fins, have evolved from wide-based fins with serially arranged basal and radial cartilages. After the formation of the primary shoulder girdle and pelvis and of the pro-, meso- and metapterygia by fusion and growth of the basals, the various types of paired fins seen in plagiostomes, chimæroids, pleuracanths, dipnoans, crossopterygians and actinopterygians seem to have arisen in each case through the protrusion of the basal cartilages, differential growth and shifting of the radials, and in some cases (*e. g.*, pleuracanths, crossopterygians, dipnoans) also through the extension of the radials around to the post-axial side of the metapterygial axis. If the Amphibia have descended from forerunners of teleostomous and dipnoan fishes (as seemed likely), then it was entirely probable that their paired fins had been transformed into limbs through the extreme protrusion of the proximal cartilages, differential growth and regrouping of the more distal cartilages, reduction of the dermal rays. This structural change may well have been in large part effected before the air-breathing proto-amphibians had left the water, owing to the assumption of a new function in the paired fins, *i. e.*, pushing against solid objects such as roots in the stagnant water, instead of merely steering. A study of the pectoral girdle and fins of *Sauripteris*, a rhizodont crossopterygian of the Upper Devonian, in comparison with those of *Polypterus* and with

the limbs of primitive amphibians, had suggested the following provisional homologies:

Crossopterygian	*Tetrapod*
"Infraclavicle"	= Clavicle
"Clavicle" (of Parker)	= Scapula
"Supraclavicle"	= Cleithrum
"Coracoid" (hypocoracoid)	= Coracoid (or precoracoid?)
"Scapula" (hypercoracoid)	= Humerus
Proximal basals	= Radius and ulna
Distal basals	= Carpals
Radials	= Metacarpals and phalanges
Dermal rays (derived from scales)	= Nails, scales

The reduction and loss of the post-temporal may have accompanied the freeing of the shoulder girdle from the skull. These views differ radically from those of Owen, Parker and Gegenbaur. The paired fins of *Sauripteris* were the only ones known that seemed to foreshadow even in a remote degree the paired limbs of the Tetrapoda. In the pelvic fin of *Eusthenopteron*, another crossopterygian of the Upper Devonian, differential evolution of the basals and radials had brought about certain remote resemblances to the tetrapod limb. The ilium of tetrapods appeared to be a neomorph.

The Section then adjourned.

L. Hussakof,
Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

20 February, 1911.

By permission of Council, no meeting was held.

Edward J. Thatcher,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

27 February, 1911.

Section met in conjunction with the American Ethnological Association at 8:15 p. m., Gen. Joseph Grant Wilson presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

Robert H. Lowie, Women's Societies of the Missouri Village Tribes.

Summary of Paper.

Dr. **Lowie** said in abstract: Like the men's military organizations, the women's societies of the Hidatsa and Mandan were arranged in a series of age-grades, membership in each of which was acquired by collective purchase. The element of purchase was the determining factor, inasmuch as a woman retained her membership, regardless of age, as long as it was not purchased of her by some other individual. In several of the women's organizations, there was a clearly marked magico-religious element, which seems to have been lacking in the men's age-grades. Thus, the Goose society was associated with the planting of corn, and the Buffalo women's society was believed to control the coming of a buffalo herd.

The Section then adjourned.

F. Lyman Wells,
Secretary.

BUSINESS MEETING.

6 March, 1911.

The Academy met at 8:15 p. m. at the American Museum of Natural History, Vice-President Kunz presiding in the absence of President Boas.

The minutes of the last business meeting were read and approved.

The following candidates for active membership in the Academy, recommended by Council, were duly elected:

Edwin C. Jameson, 35 West 49th Street,
Frederick G. Agens, Newark, N. J.

The Academy then adjourned.

Edmund Otis Hovey,
Recording Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

6 March, 1911.

The Section met at 8:22 p. m., Vice-President George F. Kunz presiding. Seventeen members and visitors were present.

The minutes of the last meeting of the Section were read, corrected and approved.

The following programme was then offered:

G. Sherburne Rogers, GEOLOGY OF THE CORTLANDT SERIES AND ITS EMERY DEPOSITS.

A. W. Grabau, NORTH AMERICAN TYPES OF LOWER PALEOZOIC SEDIMENTATION IN NORTHERN SCOTLAND.

A. A. Julien, THE EVIDENCES FROM THE PALISADES ON THE GENESIS OF ANTIGORITE. (Read by title.)

SUMMARY OF PAPERS.

Mr. **Rogers** illustrated his talk on the distribution and structure of the Cortlandt Series with many lantern slides. Remarks were made by Professor J. F. Kemp.

Dr. **Grabau** emphasized the similarity of development in corresponding sections of Europe and America and made some general suggestions as to former land connections.

The Section then adjourned.

CHARLES P. BERKEY,
Secretary.

SECTION OF BIOLOGY.

13 MARCH, 1911.

Section met at 8:15 P. M., Vice-President Frederic A. Lucas presiding.

The meeting was devoted to the following public lecture:

George A. Soper, SCIENTIFIC ASPECTS OF THE WORK OF THE METROPOLITAN SEWERAGE COMMISSION.

Dr. **Soper**, President of the Metropolitan Sewerage Commission, has done a great amount of scientific work in connection with the investigations of the commission upon the pollution of the waters of New York harbor from various sources. The most interesting features of this work and its results were dwelt upon in popular manner by the lecturer. The paper was illustrated with lantern slides.

The Section then adjourned.

L. HUSSAKOF,
Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

20 March, 1911.

Section met at 8:15 P. M., Vice-President Campbell presiding.

The minutes of the last meeting of the Section were read and approved.

The programme for the evening consisted of the following lecture:

G. W. Ritchey, Recent Celestial Photographs with the 60-inch Reflector of the Mt. Wilson Observatory.

Summary of Paper.

Professor **Ritchey** first of all spoke of the large telescopes of the world and showed various illustrations of them and photographs obtained. Then he described the 60-inch reflector, the method of manufacture and the building of the observatory at Mt. Wilson and showed his wonderful photographs obtained there.

The Section then adjourned.

Edward J. Thatcher,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

27 March, 1911.

Section met at 8:15 P. M., Gen. James Grant Wilson presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

Paul R. Radosavljevich, Cephalic Indices in Relation to Sex, Age and Social Conditions.

Franz Boas, Notes on the Indian Tribes of Mexico.

Summary of Papers.

Dr. **Radosavljevich** illustrated his lecture by charts. A discussion, in which Dr. Fishberg and Professor Boas took part, developed with reference to the possibility of accuracy in certain measurements taken on living individuals. Dr. Radosavljevich apologized to Professor Boas for having unconsciously misrepresented his theories regarding the cephalic index.

Professor **Boas's** talk was based on his recent investigations during a several months' sojourn in Mexico.

The Section then adjourned.

F. Lyman Wells,
Secretary.

BUSINESS MEETING.

3 April, 1911.

The Academy met at 8:18 P. M. at the American Museum of Natural History, Vice-President Kunz presiding in the absence of President Boas.

In the absence of the Recording Secretary, Dr. Charles P. Berkey was elected Recording Secretary *pro tem.*

The minutes of the last business meeting were read and approved.

The following candidate for active membership in the Academy, recommended by Council, was duly elected:

Professor Charles R. Eastman, Carnegie Museum, Pittsburgh, Pa.

The Academy then adjourned.

Charles P. Berkey,
Recording Secretary pro tem.

SECTION OF GEOLOGY AND MINERALOGY.

3 April, 1911.

Section was called to order by Vice-President G. F. Kunz at 8:23 P. M.

The minutes of the last meeting of the Section were read and approved.

The following programme was offered:

D. D. Condit, Observations on Volcanoes of Guatemala.
George F. Kunz, The Finding of a Great Beryl at Marambaya.
A. W. Grabau, Classification of Seas and Lake Basins.

Summary of Papers.

Mr. **Condit** gave an account of explorations made by an expedition of which he was a member in 1907 and described the principal volcanic features of the region with the aid of lantern views.

Dr. **Kunz** showed a full-size drawing of the beryl and described its character and quality, as follows: Fine minerals have come to us during the past century or more from the pegmatite rocks of Minas Geraes, Brazil, notably tourmaline, green, blue, or partly colored, chrysoberyl, topaz and other minerals, many of which have more or less gem value when in perfect condition. These have been a continual surprise to the mineralogists and gem collectors of the world. It is my purpose here to note the occurrence of one of the most remarkable finds that has ever been found in this region.

On the 28th of March, 1910, in a pegmatite vein at Marambaya, a village in the vicinity of Arassuahy, on the Jequititonha River, in the State of Minas Geraes, Brazil, there was found a crystal of beryl, the greatest crystal of precious beryl (aquamarine) ever found. In form, it was a simple hexagonal pyramid with slight irregularities due to compression, and it terminated with a simple basal plane at both ends. The crystal weighed 110.5 kilograms, was 48.5 centimeters high and from 40 to 42 centimeters in its different widths. It was so transparent that, looking down into the crystal through its basal termination, it could be seen through from end to end. In color, it was greenish-blue, absolutely free from included impurities, but it was traversed by a number of fractures.

This crystal was found by a Turk, who mined it in what is known as a primitive mine, at a depth of from five to six meters, and only with the greatest difficulty was it transported on a canoe to the coast, by way of the Jequititonha River and then shipped to Bahia, where it is said that he realized $25,000 for it. It is estimated that this crystal would furnish at least 200,000 carats of aquamarines of various sizes, although the entire quantity is not likely to glut the market as it does not represent over 5 per cent. of the annual yield. It is not of the deepest blue nor of the deepest green, yet it is an excellent sea color; the quality is excellent, and more material will be furnished than from any single crystal of any gem that we have any record of. When values become so great and buyers so few, commercialism usually asserts itself. In this instance, it is believed that a net profit of $100,000 will be realized.

Professor **Grabau** gave an elaborate classification of lake basins with the aid of a chart prepared for this purpose.

The Section then adjourned.

Charles P. Berkey,
Secretary.

SECTION OF BIOLOGY.

10 April, 1911.

Section met at 8:15 p. m., Vice-President Frederic A. Lucas presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

Roy C. Andrews, A New and Peculiar Porpoise from Japan.

J. T. Nichols, Observations on Birds and Fishes Made on an Expedition to Florida Waters.

Summary of Papers.

Mr. **Andrews** exhibited photographs and parts of the skeleton of a new porpoise secured in the summer of 1910, in Rikuzen province, Japan. This specimen is allied to *Phocœna dalli* True and with that species forms a distinct group of *Phocœna*-like porpoises which deserves generic rank. This group resembles *Phocœna* externally but has white side and ventral areas sharply defined from the black of the upper parts, a falcate dorsal fin and vertebræ numbering 95 or more. The type of the new genus to which *Phocœna dalli* was referred is the specimen which was secured in Japan and has been formally described in a *Bulletin* of the American Museum of Natural History, now in press. The Japanese porpoise presents characters, both externally and in the skeleton, which distinguish it from all other members of the entire family. The caudal peduncle shows a strongly marked "hump," and ventrally a prominent concavity which gives the posterior portion of the body a most extraordinary appearance. The neural spines of the entire vertebral series are extremely long and slender, reaching a height much greater than in any other known member of the *Delphinidæ*. The transverse processes are also very long and rod-like. The number of vertebræ is 95, approaching closely *P. dalli,* which has 97. The scapula is unlike that of any other member of the family in that its height almost equals its greatest breadth, and it is in general shape somewhat like that of a Baleen whale. The specimen is, on the whole, one of the most remarkable members of the Delphinidæ that have thus far been discovered.

Mr. **Nichols** gave an account of a trip through Florida waters on Mr. Alessandro Fabbri's yacht *Tekla* in the interests of the American Museum's department of fishes. Attention was called to the abundance of the white ibis and Louisiana heron, contrasted with the scarcity of aigrette-bearing herons. After a brief mention of the work and the results obtained, the balance of fish-life in a fresh-water outlet of the everglades was compared with the balance of fish-life in the salt water as at Key West. In the former situations, gar pikes (*Lepisosteus*) were abundant, as were various Centrarchids (among them the large-mouthed bass and blue-gill sunfish) which darted in and out through the little channels among the weed but which did not drive head first through the masses of weed as did the leathery-skinned gars, and only made quick sallies into the shallower and less open waters, where various species of Pœciliids, especially *Gambusia,* and *Fundulus goodei* were tremendously abundant. The surprising freedom from mosquitoes was mentioned,

and it was pointed out how the existing balance of fish-life was favorable to a great abundance of *Gambusia*, etc., which might be expected to prey on mosquito larvæ. The Centrarchids would be likely to hold in check a fish like the banded pickerel, which would have followed these small fishes into the shallows where the Centrarchids did not follow them and perhaps materially reduce their numbers. The situation here, where the large primitive gar, the spiny-rayed modern Centrarchids and the abundant intermediate Pœciliids made up the bulk of the fish population, was compared with the more complicated marine situation where large selachians and spiny-rayed basses, snappers, grunts, wrasses, scorpion fishes, etc., and schooling herrings and anchovies of various sorts in a way constituted homologous classes. The paper was illustrated with lantern slides.

The Section then adjourned.

L. Hussakof,
Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

17 April, 1911.

By permission of Council, no meeting was held.

Edward J. Thatcher,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

24 April, 1911.

Section met at 8:15 p. m., in conjunction with the New York Branch of the American Psychological Association. The afternoon session was held at the Psychological Laboratory, Columbia University, and the evening session was held at the American Museum of Natural History.

The following programme was offered:

George R. Montgomery,	A Simple Method for the Study of Entoptic Phenomena.
J. E. Wallace Wallin,	The Preferred Length of Interval.
E. K. Strong, Jr.,	Sex and Class Differences in Response to Advertisements.
E. L. Thorndike,	The Curve of Work.
H. L. Hollingworth,	The Influence of Caffein on the Quality of Sleep.
W. P. Montague,	Has Psychology Lost Its Mind?
I. Woodbridge Riley,	The Spread of Christian Science.
E. W. Scripture,	Psychanalysis and the Interpretation of Dreams.

SUMMARY OF PAPERS.

Mr. **Montgomery** said in abstract: By using small silver beads strung on a wire in a spectacle frame to reflect light into the eye, we have a simple method which has many advantages in the study of entoptic phenomena. From the standpoint of psychology, perhaps the most important use of such an instrument is in the study of iris movements. For some experiments, it is well to cover the frame with a black cloth, allowing the light to reach the beads through a slit. If three beads are used, they may be moved back and forth and the intensity of the light increased or diminished until the middle circle of light thrown upon the retina is exactly tangent to the other two. Such a contrivance allows a view of both pupils at the same time. It also allows careful measurement of dilation and contraction and furthermore permits the eye and the body to take an easy, normal position. The use of a single bead with two or three sources of light enables one to diversify the intensity of the circles of light thrown upon different parts of the retina. This is important in determining the parallax of objects in the eye which throw the shadows. Combinations are possible with this arrangement and other experiments, Purkinje's for instance, and the beads may also be used for throwing circles of lights from colored globes upon the retina. These circles may be superposed, the different parts of the retina compared as to color sensation, the effect of contrast brought out, etc.

Mr. **Wallin** detailed the experimental results of two simple methods of investigating the preferred length of auditory intervals; a method of impression, in which a preference was reached by successive comparisons of pairs of metronome clicks in a definite order; and a method of expression, in which the preference for musical tempos was determined by measuring the durations between the responses (stamps of the foot) made to musical selections by the gallery patrons in theaters. The results showed, among other things, that the average interval preference with metronome clicks corresponded precisely with the average tempo of the most vigorous responses to musical rhythms (0.51 sec.); that the very general tendency to rhythmize recurrent auditory impressions of the same intensity (metronome clicks) often rested on an ascertainable qualitative basis; that the tendency to perceive different lengths of auditory intervals as indifferent or neutral is infrequent; that instead of selecting a definite, invariable central tendency in respect to interval preferences, the subjects can be arranged most naturally into a number of types (slow, medium, fast, rapid); that the absence of a clear, definite central tendency is due to the fact that the preferences are determined

by varying factors permanently or temporarily operative (physical pain, mental disquietude, repose, strain of suspense or expectation, stimulation to movement, rhythmical tendency, associations, suggestions, preference for melody, harmony, or rhythm in music, but not musical capacity, etc.); that we can lay down limits within which the preferences for intervals and musical tempos will most probably come (0.40 to 0.70 sec.); and that the vigor of the responses in music varies according as the time is two-four or three-four, and according to the relative influence of other factors than that of speed (catchiness or familiarity of the music, incisiveness of the accent, etc.).

Dr. **Strong** said in abstract: In an extensive study of the relative values of the motives, which are used in advertisements, that lead one to buy toilet soap, a number of interesting facts as to class and sex differences were noted. It was found that the order of preference for such motives as were obtained from fifty college students correlated very high with similar orders from educated men and from educated women. In fact, there were no specific differences between such orders. But an order of preference from a group of one hundred men living in and about Garrison, N. Y., showed a negative correlation. The striking point about this latter order, however, was not so much that uneducated persons do not agree with educated ones with respect to which are the strong motives, but that they do not agree amongst themselves at all—their order being little more than a chance order. This is the more striking when we realize that two groups of educated women correlated as high as + .93. In this study, it was very clear that women are less variable in their judgments as to the merit of these motives or appeals than are men. Not only were the corresponding probable errors of the medians smaller in almost every case among the women, but the various sub-groups of women correlated higher with respect to each other than did the sub-groups of men. Such motives as "beauty" and "for the baby" ranked higher among the women than among the men, but the surprising thing here was that the two sexes agreed so closely with respect to the other motives.

Professor **Thorndike** reported results of five subjects, each working eight hours (two hours on each of four days) at adding printed examples, each of ten one-place numbers. It was found that initial spurt did not appear at all as a general tendency in all students, or consistently in the work of any one of them. There was a slight tendency to spurt in the last five minutes, but this was very slight and by no means consistent throughout the group, or important in the case of any member of the group. Warming up was found to play a slight and possibly inap-

preciable part in the curve of work. The influence of practise and that of fatigue approximately balanced, so that the general tendency of the character of the work is not only toward rectilinearity, but also toward parallelism with the base line.

Dr. **Hollingworth** said in abstract: Sixteen subjects were given doses of caffein alkaloid (1-6 grains), at varying times of day, for a period of a month. Incidentally to a series of mental tests which were continued throughout this period, each subject recorded the approximate number of hours' sleep after each day and graded the quality of the night's rest as "better than usual," "ordinary," or "worse than usual." Adequate control methods were used. Clear individual differences were shown in the effect of the drug on the quality of sleep—and these differences were independent of age, sex and size differences. On the basis of the squad averages, doses of 1-4 grains do not impair sleep. Doses larger than these produce sleeplessness. This effect is greatest when the dose is taken day after day, allowing a cumulative effect. When a single dose is taken on alternate days, the effect is greatest when the caffein is taken between meals. Taken with meals, its action is weakened and retarded. Only in exceptional cases does sleeplessness follow the 1-4 grain dose, and in many cases a 6-grain dose is without effect. The "approximate number of hours" of sleep does not seem to be modified by the action of the drug, probably because this matter is controlled by a more or less artificial schedule.

Dr. **Montague** said in abstract: The movement to dispense with the concept of mind or consciousness and to substitute the concept of behavior as the sufficient object of psychological study was criticized (1) on the ground of ambiguity and (2) on the ground of inadequacy.

1. Behavior, as the movement of an organism in response to stimulus, is ambiguous in that it may mean (*a*) the intra-neural current from sensory center to muscle, or (*b*) the extra-neural motion of the organism or its members. Behavior in the first sense might conceivably be the basis of and hence a substitute for consciousness, but it would be visible to the external observer and therefore relatively useless as an object of psychological study. Behavior in the second sense is visible to the observer, and so a useful index of consciousness; but being extra-neural, it could not possibly be the correlate or basis of the organism's own experience. The motor theory of consciousness derives much of its plausibility from an unconscious shifting from one of these meanings of behavior to another.

2. But behavior in either or both of these senses is inadequate as a substitute for or even as a correlate of consciousness, (*a*) because, unless

evidence is given for an innervation sense, it can only be the kinesthetic sensations that result from one's movement, and never the movement itself, that one experiences; hence, to reduce consciousness to movement would be to reduce all sensations to kinesthetic sensations; (*b*) because the field of consciousness is infinitely too rich a manifold to be put in one to one correspondence with any system of mere motions, internal or external.

Mr. **Riley** said in abstract: From recent investigations made by Professor Joseph Jastrow comparing the results of the Federal Census of 1910 with the number of advertised Christian Science practitioners, there is shown a three-fold distribution of the sect, chiefly in three pairs of states: Massachusetts and New York, Illinois and Missouri, Colorado and California. Here the pathological factor is first in evidence, for the centers of influence are large cities, with their concomitant nervous disorders, and the health resorts of the mountains and coast. A second factor is that of free thought, or a liberal attitude toward the unconventional such as is found in the given states, with their large cities and their great number of imported foreign faiths. A third factor is financial, a reaction from overmuch material prosperity and a leaning towards a somewhat ascetic immaterialism. This leads to the final factor, the previous idealisms which prepared the soil, such as New England transcendentalism, with the Emersonian call to the "demonstration" of the "spiritual principle," and the German idealism represented in the St. Louis School. These four factors apply not only to the followers of Christian Science, but to the founder; and here Eddyism may be considered not only an afterclap of transcendentalism, but a recrudescence of Neoplatonism. As in Rome and Alexandria, so in America, there has arisen a demand for knowledge dependent on "divine" communications; a denial of sensible existence; a contempt for reason and physical science, and a destruction of the distinction between sensible and intelligible. In all this, Christian Science shows itself a recurrent phase of the larger movement of so-called New Thought, with its occultism, gnosticism and mysticism. The type of mind to which the movement appeals is complex—practical and yet uncritical, non-academic and yet speculative. Such a mind fails to distinguish the fundamental fallacy of Christian Science—that while it disclaims materialism, it still reeks with material terms such as "mental offshoots," "gravitation Godward," and the "aroma of Spirit." In fine, the "divine metaphysics" bolsters itself up with the latest physical discoveries, such as Hertzian waves and X-rays, to explain "absent treatment" and silent "demonstration."

Dr. **Scripture** said in abstract: Psychanalysis is the term applied to the line of work originated by Freud, of Vienna. Its chief object is to get at the facts of the subconscious. One of its most effective methods is the analysis of dreams. The immediate facts in the dream, the "manifest content," are derived from the immediately preceding experiences of life. The "latent content" is deduced from the "manifest content." The "latent content" of a dream always consists of a wish or fear. A child disappointed by the size of some Bantam chickens dreamed that she had large Cochin Chinas and thus satisfied her wish. A man dreams that he is bald because he has noticed his hair to be getting thin and fears that he will become bald. The "manifest content" of the dream is often symbolic of the "latent content." After a consultation with his physician in which the disagreeable experiences of his past life are discussed, a man dreams of being in a laundry watching the clothes boil in the tank. His dreams satisfies the wish to see his "dirty linen" washed clean. A man in financial difficulties dreams of being caught in a terrific snow-storm. This expresses his fear of being "snowed under." By psychanalysis, the physician gets an accurate knowledge of the patient's mental make-up; this he can get in no other way. He can then proceed to correct the various defects of character, such as egotism, stubbornness, viciousness, bashfulness, timidity, etc. Psychanalysis is the only radical cure for hysteria, the phobias and psychasthenia.

The Section then adjourned.

F. Lyman Wells,
Secretary.

BUSINESS MEETING.

1 May, 1911.

The Academy met at 8:15 p. m. at the American Museum of Natural History, Vice-President Kunz presiding in the absence of President Boas.

The minutes of the last business meeting were read and approved.

There being no business to transact, the Academy then adjourned.

Edmund Otis Hovey,
Recording Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

1 May, 1911.

Section was called to order at 8:18 p. m. by Vice-President George F. Kunz, about 55 members and visitors being present.

The minutes of the last meeting were read and approved.

The following programme was then offered:

E. O. Hovey,	THE COPPER QUEEN MINE, BISBEE, ARIZONA.
James G. Manchester,	NEW DISCOVERY OF GEM STONES ON MANHATTAN ISLAND.
J. F. Kemp,	THE SARATOGA MINERAL SPRINGS.
A. W. Grabau,	SOME SILURIC CORAL REEFS OF EUROPE.

SUMMARY OF PAPERS.

Dr. **Hovey** exhibited a sketch model of the famous Copper Queen mine and explained the lines on which the complicated geological features of the locality were to be graphically represented. Remarks were made by Professor Kemp and Dr. Berkey.

Mr. **Manchester** described several localities and showed gem material from a few of them. Topaz and beryl were especially well developed in these specimens. Remarks were made by Professor Kemp.

Professor **Kemp** gave a general explanation of the geology of these springs, with suggestions of the origin of the gases and salts carried by them.

Dr. **Grabau's** paper was given with lantern illustrations, and comparisons were made with certain similar structures in America.

The Section then adjourned.

CHARLES P. BERKEY,
Secretary.

SECTION OF BIOLOGY.

8 MAY, 1911.

Section met at 8:15 P. M., Vice-President Frederic A. Lucas presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

C.-E. A. Winslow,	BACTERIA AND DECOMPOSITION IN RELATION TO THE PURE FOOD LAW.
L. Hussakof,	THE SPOONBILL FISHERY OF THE LOWER MISSISSIPPI.

SUMMARY OF PAPERS.

Professor **Winslow** discussed certain problems, which have recently arisen in connection with the application of the pure food laws, concerning the relation between bacterial multiplication and decomposition. Decomposition, in the ordinary sense of the term, is due to the action of

certain bacteria on certain substances and the mere number of bacteria, without distinction as to kinds, bears no relation to it. The best criterion for decomposition would be a chemical test for decomposition products, but no such test has yet been shown to be of general value.

Dr. **Hussakof** gave an account of a trip he had recently made to Mississippi for the purpose of collecting specimens of the paddlefish, *Polyodon spathula*, for the preparation of an exhibition group in the American Museum. This fish is one of the largest and most interesting found in our fresh waters. It is especially abundant in the lower Mississippi Valley, where it attains a length of 6 feet and a weight of 160 pounds. Some interesting facts were presented, bearing on its natural history and its commercial value. *Polyodon* roe is said to produce the best caviar in the world. The distribution of *Polyodon* and of the related Chinese fish, *Psephurus*, was discussed.

The paper was illustrated with lantern slides.

The Section then adjourned. L. HUSSAKOF,
Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

15 MAY, 1911.

Section met at 8:15 P. M., Vice-President Campbell presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

William Campbell, NOTES ON ANTIFRICTION METALS.

SUMMARY OF PAPER.

Starting with a series of Thormal diagrams for binary alloys, Dr. **Campbell** developed certain ternary diagrams and explained many of the common bearing metals thereby. Then, by means of lantern slides, the following systems were discussed and their structures shown:

1. Lead antimony tin.
2. Tin antimony copper.
3. Lead tin antimony copper.
4. Zinc-rich alloys such as lumen, etc.
5. Tin-zinc-rich alloys: Parson's white brass, etc.

Then by way of contrast, numerous alloys rich in copper, with and without lead, which are used for bearing, were shown and their structures and properties explained.

The Section then adjourned. EDWARD J. THATCHER,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

22 May, 1911.

By permission of the Council, no meeting was held.

BUSINESS MEETING.

9 October, 1911.

The Academy met at 8:17 P. M. at the American Museum of Natural History, Vice-President Kunz presiding in the absence of President Boas.

The minutes of the last business meeting were read and approved.

The following candidate for active membership in the Academy, recommended by Council, was duly elected:

Silas C. Wheat, Brooklyn, N. Y.

The Recording Secretary *pro tem* then reported the following deaths:

Mrs. Esther Herrman, a Patron for 30 years,
Charles H. Senff, a Patron for 16 years,
G. Johnston Stoney, an Honorary Member for 8 years,
A. B. Meyer, a Corresponding Member for 22 years,
Samuel Scudder, a Corresponding Member for 35 years.

The Recording Secretary *pro tem* reported that invitations had been received by the Academy to send accredited delegates to centennials and celebrations of the Natural History Society in Görlitz, the National University of Greece, the Sixteenth International Congress of Orientalists and the Eighteenth International Congress of Americanists. Council will take steps to ascertain whether any foreign or corresponding members of the Academy are likely to be present at such celebrations to serve as accredited delegates.

Council also reported favorable consummation of the negotiations with the St. Louis Academy of Sciences for the mutual exchange of publications. Similar arrangements are to be taken up with the California Academy of Sciences and the Chicago Academy of Sciences.

The Recording Secretary *pro tem* reported that the President had appointed a committee consisting of Professors James F. Kemp and Henry E. Crampton to prepare a suitable minute relative to the recent decease of Mrs. Esther Herrman, to be spread upon the minutes of the Academy and to be sent to the relatives of Mrs. Herrman. Professor Kemp thereupon presented the following minute:

The death of Mrs. Esther Herrman the past summer has removed from the circle of the New York Academy of Sciences one of its oldest members and one of its most generous supporters. Mrs. Herrman was elected in 1881, and has thus for full thirty years been a member and patron. Thirty years ago, the Academy was divided into three classes: members, patrons and subscribers to the building fund. The last named group reminds us of the ambitions which had been cherished that the Academy should possess its own home. When, some fifteen years after, the movement under the guidance of the Scientific Alliance took on new life and vigor, Mrs. Herrman contributed the extremely generous sum of ten thousand dollars toward the fund. As years followed, however, it seemed impossible to complete the large sum required, and when the present close affiliation with the American Museum of Natural History became established, the need of a permanent meeting place no longer existed. Mrs. Herrman then permitted the fund to become an endowment whose income should be applied by the Council of the Academy in the form of grants for research. In this form, the Esther Herrman fund is administered, and will for all the future keep the memory of the generous donor ever living in the minds of our members.

Mrs. Herrman was active in many other good works and societies in the City. Universally beloved for her great kindness and profoundly esteemed for the intelligent interest which she took in the various organizations with which she was connected, she was one of the large-hearted citizens who make up the best life of the metropolis.

Therefore, be it resolved that this minute be spread upon the records of the Academy and that the Secretary be instructed to transmit a copy to the family of Mrs. Herrman.

Vice-President Kunz spoke briefly of the important work performed by Dr. A. B. Meyer, whose death was reported upon.

The Academy then adjourned.

Henry E. Crampton,
Recording Secretary pro tem.

SECTION OF GEOLOGY AND MINERALOGY.

9 October, 1911.

Section was called to order at 8:30 p. m. by Vice-President George F. Kunz, twenty members and visitors being present.

The minutes of the last meeting of the Section were read and approved.

There being no special business, the regular scientific programme as announced was presented:

D. D. Condit, The Sands of Ohio.

Charles P. Berkey, Prominent Structure of the Northern Margin of the Highlands.

A. W. Grabau, Some Structural Features of the Helderberg Front.

Summary of Papers.

Mr. **Condit's** paper was read by Professor James F. Kemp. A very large number of sands had been studied by Mr. Condit in considerable detail, especially for type of grain and range in mineralogic composition. It seems to establish that sands of the same origin or general source have definite characteristics which distinguish them from others. Comparison of these types of sands has led the author to conclude that the very general absence of certain metamorphic mineral grains, such as garnet, from the earlier sands may have a deeper significance. He suggests that their absence may mean that the metamorphic products are of later date.

Remarks were made by Dr. Charles P. Berkey, in which attention was called to the sweeping nature of the conclusion suggested by Mr. Condit and pointing out other possible reasons for such widespread failure of the metamorphic grains.

Dr. George F. Kunz remarked the wide range of specific gravities represented in the list of minerals determined by Mr. Condit and drew attention to the differences of behavior that this would bring about in the processes of assorting and deposition.

Professor A. W. Grabau called special attention to the part of the paper dealing with size of grains and evidence of their wear and emphasized the work of wind in connection with the development of the great sandstone formations.

Dr. **Berkey** gave special attention to the results of recent studies in the Moodna Valley and adjacent ground. The great thrust which passes through Cornwall on the Hudson was classified, and some of the data bearing upon its importance and the amount of displacement involved were given. It is the author's opinion that a total displacement of 2,000 feet or more is indicated by conditions at this fault. Lantern slides of the fault were shown. Remarks were made by Professor J. F. Kemp.

Professor **Grabau** described and illustrated the complex structure including faults and folds as recently determined by him in the Helderberg limestone strata near Catskill. Diagrams showing reconstructions of the formational positions were shown.

The Section then adjourned.

Charles P. Berkey,
Secretary.

SECTION OF BIOLOGY.

16 OCTOBER, 1911.

Section met at 8:15 P. M., Vice-President Frederic A. Lucas presiding.

The minutes of the last meeting of the Section were read and approved.

The meeting was devoted to the following illustrated lecture:

Charles H. Townsend, THE VOYAGE OF THE *Albatross* TO THE GULF OF CALIFORNIA.

SUMMARY OF PAPER.

In the spring of 1911, the *Albatross,* under the direction of Dr. **Townsend**, Director of the New York Aquarium, made a natural history survey of the Gulf of California. Much valuable information was obtained bearing on the oceanography and the general biology of this region, and especially the deep-sea forms. After stating that the American Museum of Natural History, the New York Zoölogical Society, the New York Botanical Garden and the United States National Museum coöperated in the voyage of the *Albatross* by special arrangement with the U. S. Bureau of Fisheries, Dr. Townsend gave a general account of the work done. The *Albatross* sailed from San Diego. Twenty-six hauls of the dredge were made, the deepest being 1,760 fathoms. Shore work was carried on at 32 anchorages around the peninsula of Lower California and at islands in the gulf. Important collections of mammals, birds, reptiles and plants were made. A special study was made of the fishery resources of the region. An interesting feature of the expedition was the rediscovery of the supposed extinct elephant seal, *Mirounga.* About 100 of these animals were found at Guadeloupe Island, which is uninhabited. Six yearlings were sent alive to the New York Aquarium, and three large males and a female were secured for skins and skeletons. The males were each 16 feet long. Excellent photographs were made. Among the interesting things obtained by dredging were *Harriotta* and *Cyema,* two deep-sea fishes not previously recorded from the Pacific.

The Section then adjourned.

L. HUSSAKOF,
Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

23 OCTOBER, 1911.

Section met at 8:15 P. M., Vice-President Campbell presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

William Campbell, SOME RECENT DEVELOPMENTS IN METALLURGY.

SUMMARY OF PAPER.

Professor **Campbell**, starting with the definitions of metallurgy and metallography, first discussed the structure of metals and the effect of annealing such material as drawn or rolled nickel contrasted with that of very low carbon steel (Stead's Brittleness). The modern classification of alloys, according to solubility in the liquid and solid states, was illustrated with examples such as monel metal, the brasses, the lead-tin solders and the lead-antimony group. Changes in the solid state were shown by the bronzes with Shepherd's diagram; iron and steel with the various diagrams from the Rooseboom-Roberts Austen to Upton; the effect of heat-treatment, hardening and tempering. The ternary alloys were illustrated by the white metals, lead tin antimony, tin antimony copper; by German silver, plastic and phospher bronzes, etc. Finally the work of Friederich on sulphides and arsenides and of the Geo-Physical Laboratory on silicates was summarized.

The Section then adjourned.

EDWARD J. THATCHER,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

30 OCTOBER, 1911.

Section met at 8:15 P. M., Gen. James Wilson Grant presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

Marshall H. Saville, TRAVELS IN THE LAKE REGION OF NORTHERN ECUADOR.

The Section then adjourned.

F. LYMAN WELLS,
Secretary.

BUSINESS MEETING.

6 November, 1911.

The Academy met at 8:25 P. M. at the American Museum of Natural History, Vice-President Kunz presiding in the absence of President Boas.

The minutes of the last meeting were read and approved.

The Recording Secretary reported the following deaths:

Elliott C. Smith, Active Member for 6 years,

The Recording Secretary also reported the acceptance of an invitation to participate in and send delegates to the Eighth International Congress of Applied Chemistry.

The Recording Secretary spoke of the desirability of the Academy becoming a member of the Seismological Society of America, and on motion it was voted to refer the matter with approval to the Council for action.

The Academy then adjourned.

Edmund Otis Hovey,
Recording Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

6 November, 1911.

Section met at 8:35 P. M., Vice-President George F. Kunz presiding, twenty-five members and visitors being present.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

George F. Kunz, On the Occurrence of Opal in Northern Nevada and Idaho.

After the discussion of Dr. Kunz's paper, several brief accounts of scientific observations were made by members of the Section. Dr. E. O. Hovey gave a preliminary note on Meteor Crater, or "Coon Butte," Arizona. This was based on a personal visit recently made by Dr. Hovey. The view that this remarkable depression has been formed by meteor impact is believed to account for the facts observed on the ground. Remarks were made by Professor Martin calling attention to Mr. Gilbert's impact theory for the origin of lunar craters also.

Professor Kemp called attention to Mr. Gilbert's experimental work on the forms of wounds that can be made by impact of clay pellets against a clay background.

Recent discoveries of shell remains buried beneath the drift of Lower Manhattan Island were noted by Professor J. F. Kemp.

At the close of this scientific programme the required business of the Section was taken up.

Dr. Hovey nominated and Professor Kemp seconded Professor J. E. Woodman, of New York University, as chairman of the Section and Vice-President of the Academy. After the casting of the ballot of the Section, Professor Woodman was declared the nominee to be recommended to the Council.

Dr. C. P. Berkey was nominated and elected Secretary of the Section.

Summary of Paper.

Dr. **Kunz** described the finds of opal and the characteristics of the gem and showed cut specimens. He said in abstract: For the past twenty-five years, there have been found over quite a region at the juncture of southwest Idaho, southeast Oregon and northern Nevada small specimens of opal as float in various parts of the region. Opals from Drewsey, Oregon, have been described by the writer and also specimens from Washington State, the opal being found quite a distance to the north. In 1889, there was sent to New York a specimen of opal one inch long, half an inch wide and one-quarter of an inch thick that was good fire opal: a drift pebble, either out of some gravels or a river bed. The color was excellent and quite equal to the pale yellow fire opal from Queretaro, Mexico.

About three years ago, some specimens of opal were found in northern Nevada, at a point west of the Santa Rosa Mountains. This was of what is known as the fire-opal variety, not precious opal such as was found in Washington State; indeed, it rather resembled certain types of the Mexican opal from the State of Queretaro. Of these Nevada opals, some represent the absolutely transparent, pellucid type, either with large flames of color, or else with a smaller harlequin flaking. These change perceptibly into pale yellow, yellow brown, brown, and sometimes they are only sub-translucent but with a great play of color which changes finally into black. A number of shades include a black, strongly resembling the hue of certain types of crude petroleum, or that of the darker types of Burman or Roumanian amber.

More recently, another locality has been found eight miles from that

above noted. This has furnished a number of specimens remarkable for their large flames of red, strongly resembling lumachella marble. A number of these are lusterless, and many of them are more or less cracked, partly due to the fact that they have a large water content, and partly because a number of them have been found very near the surface. In some respects, the formation resembles the deposit discovered in White Cliffs, New South Wales, where some of the opals are pseudomorphs, being opals after wood or other objects. There was a newer find in 1911, a limb of a tree measuring fifty centimeters, or nearly two feet, in length and eight centimeters across; this was entirely changed to opal; the outer parts were very brilliant, whereas the center was of the dull, common opal variety. Some of the opals are equal to the finest Mexican material, the colorless and a number of new varieties.

In nearly every instance, these masses are found in decomposed volcanic rock, or in ash that has hardened. Apparently there must have been a later flow of opaline waters to change them to this form. The deposit is west of the Santa Rosa Mountains and near the Trout Forest Range and the Pine Forest Range. Some of the stones cut several years ago still hold their color, but it is possible that a number of them may not be of the more durable type. This is the most interesting occurrence of opal that has yet been noted in the United States. The deposit found in 1909 was traced to a depth of 16 feet, whereas the opalized tree and later deposits above mentioned were found at a depth of only two feet.

There have at various times come to me various opal from Lovelock, in the southern part of Humboldt Co., Nevada, and wood opal from the northeastern part of Humboldt Co.; also opal in concretionary masses from Austin in the southeastern corner of Lander County, as well as from Caldwell, Idaho, Rockville and Score Creek, Owhyhee County, Idaho. There was opal also from Clover Creek, Lincoln County, in the Snake River region in the southwestern part of Idaho and from Baker and Durkee in Oregon, Walla Walla, Douglas County, and Whelan near Mexico, Idaho, as well as near the Salmon River. This furnished the finest precious opal that has been found on the continent, the opal occurring as nodules in a very hard trachitic rock resembling the rock in which the precious opal is found in Hungary. A single stone was worth one thousand dollars. An impure variety has been found in Dunsmuir, Siskiyou Co., northern California. Opal is also found in the desert near Reno, and it is possible that it may be found in many places near there, both in excellent gem varieties as well as the finer qualities. Remarks were made by Professor Martin.

The Section then adjourned. CHARLES P. BERKEY,
Secretary.

SECTION OF BIOLOGY.

13 NOVEMBER, 1911.

Section met at 8:15 P. M., Vice-President Frederic A. Lucas presiding.

The minutes of the last meeting were read and approved.

Dr. Frederic A. Lucas was nominated for Vice-President of the Academy and Chairman of the Section for 1912.

Dr. W. K. Gregory was elected Secretary of the Section for 1912.

The following programme was then offered:

W. K. Gregory, FURTHER NOTES ON THE EVOLUTION OF PAIRED FINS.
C. William Beebe, NOTES ON A PHEASANT EXPEDITION TO ASIA.

SUMMARY OF PAPERS.

Dr. **Gregory** said in abstract: The problem under consideration is a phase of vertebrate phylogeny and should be studied in connection with this larger problem. In very early acquiring myotomes, the ancestral vertebrates gained a means of locomotion, by lateral flexures of the body, that was more efficient than movement by means of ciliated epidermis. The earliest vertebrates probably fed on microscopic particles obtained by ciliary ingestion. The Upper Silurian *Birkenia* of Traquair apparently had no biting jaws and may have sucked in small food particles, like the larval lamprey. Well-preserved material showed that none of the Ostracoderms had cartilage jaws or teeth, but the dermal plaques around the oral hood sometimes functioned as jaws. Typically carnivorous habits, involving true cartilage jaws, true teeth and both paired and median fins, are first known in the Acanthodian sharks, of the Upper Silurian and Devonian. In brief, fins of all kinds, conditioned in their first appearance by the presence of myotomes, were evolved as an incident in the general transformation of acraniate minute forms, with ciliary ingestion, into well-cephalized fishes of carnivorous habits. The speaker reviewed the evidence for the "fin-fold" theory in the different groups and stated some apparently new objections to the "gill arch" theory. He cited evidence tending to show that the various paddle-like types of paired fins with widely protruded basal cartilages had evolved from fin folds independently in the sharks, Crossopterygians and Dipnoans.

The paper was illustrated with lantern slides.

Mr. **Beebe** gave a short talk, illustrated with lantern slides, on the recent trip which he and Mrs. Beebe made around the world in search of

material for a monograph of the Phasianidæ. This expedition was made under the auspices of the New York Zoölogical Society and at the suggestion and by the financial support of Col. Anthony R. Kuser. In the short time at his disposal, he was able to touch only upon Ceylon and the Himalayas. In Ceylon, the junglefowl peculiar to the island and the India peafowl were studied and their nests and eggs found, and in the Himalayas every genus of pheasant was investigated, from *Gennæus melanonotus* at six thousand feet, to *Ithaginis cruentus* at an elevation of fourteen thousand feet.

The three most important points brought out were the tremendous economic importance of this group, our ignorance of their ecology and the rapidity of their extermination.

The Section then adjourned.

L. Hussakof,
Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

20 November, 1911.

Section met at 8:15 p. m., Vice-President Campbell presiding.

The minutes of the last meeting of the Section were read and approved.

Prof. Charles Lane Poor was nominated for Vice-President of the Academy and Chairman of the Section for 1912.

Prof. F. M. Pedersen was elected Secretary of the Section for 1912.

The Section then adjourned.

Edward J. Thatcher,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

27 November, 1911.

Section met in conjunction with the New York Branch of the American Psychological Association, at 8:15 p. m.

The minutes of the last meeting of the Section were read and approved.

The following programme was offered:

D. O. Lyon, The Relation of the Quickness of Learning to Retentiveness.

H. L. Hollingsworth, The Action of Pharmacological Agents as an Aid in the Classification of Mental

S. S. Colvin,	INVESTIGATIONS IN PROGRESS IN THE PSYCHOLOGICAL LABORATORY OF THE UNIVERSITY OF ILLINOIS.
J. W. Todd,	REACTION TO SIMULTANEOUS STIMULI.
D. E. Rice,	VISUAL ACUITY UNDER LIGHTS OF DIFFERENT COLORS.
A. T. Poffenberger,	REACTION TIME FOR DIFFERENT RETINAL AREAS.
R. S. Woodworth,	CORRELATIONS OF ASSOCIATION TESTS.
G. C. Meyers,	EXPERIMENTS ON INCIDENTAL MEMORY.

The Section then adjourned.

F. LYMAN WELLS,
Secretary.

BUSINESS MEETING.

4 DECEMBER, 1911.

The Academy met at 8:20 P. M. at the American Museum of Natural History, Vice-President Kunz presiding in the absence of President Boas.

The minutes of the last business meeting were read and approved.

The following candidates for membership in the Academy, recommended by Council, were duly elected:

ACTIVE MEMBERSHIP.

Dr. Joseph Byrne, 29 West 61st Street,
George Borup, New Haven, Conn.

ASSOCIATE MEMBERSHIP.

C. C. Mook, Metuchen, N. J.

The Academy then adjourned.

EDMUND OTIS HOVEY,
Recording Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

4 DECEMBER, 1911.

Section met at 8:25 P. M., Vice-President George F. Kunz presiding.

The reading of the minutes of the last meeting of the Section was dispensed with.

The following programme was then offered:

H. E. Crampton, Geological Observations on the Region of the Kaiteur Falls and Mt. Roraima, British Guiana.
Victor Ziegler, The Siliceous Oölites of Central Pennsylvania.

Summary of Papers.

The expedition described by Professor **Crampton** was undertaken for biologic rather than geologic exploration, and a great number of most interesting geological observations were made and photographs were shown covering the region seldom reached by white travellers. The general structure of the region was explained, and the general physiographic features were described in a very instructive way. Remarks were made and questions were asked by Dr. Kunz and Professors Kemp and Woodman.

Dr. **Ziegler's** paper was read by Dr. Berkey in the absence of the author. The discussion covered a summary of previous work on siliceous oölites, their occurrence and distribution, detailed sections of the rock formations and petrographic descriptions, with microphotographic illustrations and a discussion of the origin of the oölites.

The Section then adjourned.

Charles P. Berkey,
Secretary.

SECTION OF BIOLOGY.

11 December, 1911.

Section met at 8:15 p. m., Vice-President Frederic A. Lucas presiding.

The minutes of the last meeting of the Section were read and approved.

The following programme was then offered:

Henry E. Crampton, Explorations in Guiana and Brazil.
W. K. Gregory, Notes on the Origin of Paired Limbs of Terrestrial Vertebrates.

Summary of Papers.

Professor **Crampton** gave an account of a biological survey he made during the past summer from Georgetown, on the coast of British Guiana, to the mountains of Roraima—the tableland that stands at the junction of Brazil, Venezuela and British Guiana. The paper was illustrated with lantern slides.

Dr. **Gregory** said in abstract: In the problem of the origin of the Tetrapod limbs, no homological value should be attached to Klaatsch's

comparisons between the pectoral paddles of *Polypterus* and the fore limb of Urodeles until the phylogenetic relations of *Polypterus* to the Devonian Osteolepida and of the latter to the Amphibia has been evaluated, at least provisionally. Similarly, no homological value should be attached to the limb-like form and functions of the paddles of *Ceratodus* until the relationship of the latter to the Devonian Dipnoans and Osteolepida has been taken into account. That the Dipnoi are related to the Osteolepida is indicated especially by the agreement in certain histological characters of the teeth and scales, in the character of the median and paired fins, etc. If the Amphibia came off from this Pre-Devonian Osteolepid-Dipnoan stem, the hiatus in both the geological record and in the evolutionary sequence is a great one. I feel that there was cumulative evidence for the view that the Amphibia has been derived from fishes of some sort and more particularly that these fishes possess the following characters: functional gills and "lungs," homologous with those of Dipnoi and Crossopterygii, chondrocranium covered with bones having the same ultimate derivation as the scales, skull elements very largely corresponding with those of Ganoids but probably independently evolved, opercular bone reduced or absent, preoperculum giving rise to the true squamosal of Tetrapods (overlapping the quadrate), hyomandibular large, giving rise to the columella auris, scales without ganoine, primary shoulder girdle and pelvis becoming bony, body short, head large depressed, notochord persistent, fore and hind paddles similar in form and function, median and caudal fin reduced. A detailed comparison of the shoulder girdle and pectoral paddle of one of the Rhizodonts, the *Sauripterus* of Hall, with those of other fishes and Tetrapods leads to the following provisional comparisons:

Sauripterus	*Tetrapod*
"Infraclavicle" (clavicle of Oegenbaur)	Clavicle
"Clavicle" (Cleithrum of Oegenbaur)	Cleithrum
Scapulo-coracoid	Scapulo-coracoid
Single "basal piece"	Humerus
"Basals" collectively	Fore arm and carpus
"Radials" collectively	Digits

In view of the marked differences, however, in the skull between the Rhizodonts and the Amphibia, we cannot say whether these resemblances are convergent or homogenetic. The paper was illustrated with lantern slides.

The Section then adjourned.

L. Hussakof,
Secretary.

ANNUAL MEETING.

18 December, 1911.

The Academy met for the Annual Meeting on Monday, 18 December, 1911, at the Hotel Endicott, at the close of the annual dinner, Vice-President Kunz presiding in the absence of President Boas.

The minutes of the last Annual Meeting, 19 December, 1910, were read and approved.

Reports were presented by the Corresponding Secretary, the Recording Secretary, the Librarian and the Editor, all of which, on motion, were ordered received and placed on file. They are published herewith.

The Treasurer read his detailed report, showing a net cash balance of $1,356.58 on hand at the close of business, 30 November, 1911. On motion, this report was received and referred to the Finance Committee for audit.

The following candidates for honorary membership and fellowship, recommended by Council, were duly elected:

Honorary Members.

Prof. Hermann Credner, Geologist, University of Leipzig, Leipzig, Germany, presented by Prof. J. J. Stevenson.

Prof. Ernst Mach, Physicist, University of Vienna, Vienna, Austria, presented by Dr. R. H. Lowie.

Prof. Edward B. Poulton, Biologist, University of Oxford, Oxford, England, presented by Prof. Bashford Dean.

Fellows.

Prof. Charles R. Eastman, Carnegie Museum, Pittsburgh, Pa.
Prof. F. M. Pedersen, College of the City of New York, New York.

The Academy then proceeded to the election of officers for the year 1912. The ballots prepared by the Council in accordance with the By-Laws were distributed. On motion, it was unanimously voted that the Recording Secretary cast one ballot for the entire list nominated by the Council. This was done, and they were declared elected, more than the requisite number of members and fellows entitled to vote being present:

President, EMERSON McMILLIN.

Vice-Presidents, J. EDMUND WOODMAN (Section of Geology and Mineralogy), FREDERIC A. LUCAS (Section of Biology), CHARLES LANE POOR (Section of Astronomy, Physics and Chemistry), R. S. WOODWORTH (Section of Anthropology and Psychology).

Corresponding Secretary, HENRY E. CRAMPTON.

Recording Secretary, EDMUND OTIS HOVEY.

Treasurer, CHARLES F. COX.

Librarian, RALPH W. TOWER.

Editor, EDMUND OTIS HOVEY.

Councilors (to serve 3 years), CHARLES P. BERKEY, CLARK WISSLER.

Finance Committee, EMERSON McMILLIN, F. S. LEE, G. F. KUNZ.

At the close of the elections, the Recording Secretary read the address of the retiring President, Professor Franz Boas, upon "The History of the American Race."

After the reading of the presidential address, Mr. George Borup, a graduate student at Yale University, related a few of his most interesting experiences in connection with Admiral Peary's North Polar Expedition of 1908-1909. At the close of his remarks, Mr. Borup gave a concise and illuminating résumé of the scientific problems remaining to be studied in the North, including the actual visiting of Crocker Land, the land which Peary saw from Grant Land in 1906 but which lay too far to the westward for him to visit. Mr. Borup's remarks were illustrated with lantern slide views.

The Academy then adjourned.

EDMUND OTIS HOVEY,
Recording Secretary.

REPORT OF THE CORRESPONDING SECRETARY.

We have lost by death during the past year the following Honorary Members:

Sir Francis Galton, elected in 1910,
G. Johnstone Stoney, elected in 1904,

and the following Corresponding Members:

A. B. Meyer, elected in 1890,
Samuel H. Scudder, elected in 1876.

There are at present upon our rolls 47 Honorary Members and 127 Corresponding Members.

Respectfully submitted,

HENRY E. CRAMPTON,
Corresponding Secretary.

REPORT OF THE RECORDING SECRETARY.

During the year 1911, the Academy held 8 business meetings and 27 sectional meetings, at which 61 stated papers were presented on the following subjects:

Geology, 14 papers; Mineralogy, 5 papers; Biology, 14 papers; Anthropology, 3 papers; Ethnology, 2 papers; Psychology, 16 papers; Physics, 6 papers; Chemistry, 1 paper.

Two public lectures have been given at the American Museum to the members of the Academy and the Affiliated Societies and their friends, as follows:

"Recent Celestial Photographs with a Sixty-Inch Reflector of the Mount Wilson Observatory." By G. W. Ritchie.

"The Depths of the Sea." By Sir John Murray.

At the present time, the membership of the Academy includes 502 Active Members, 19 of whom are Associate Members, 120 Fellows, 90 Life Members and 11 Patrons. The election of 3 Fellows is pending. There have been 10 deaths during the year, 26 resignations have become effective, 7 names have been dropped from the roll on account of non-payment of dues, 1 name has been transferred to the list of Life Members and 1 has been transferred to the list of Non-Resident Members. Nine new members have been elected during the year. As the membership of the Academy a year ago was 538, there has been a net loss of 36 during the year 1911. Announcement is made with regret of the loss by death of the following members:

Bernard G. Amend, Active Member for 45 years,
William G. Davies, Active Member for 35 years,
C. A. Herter, Active Member for 17 years,
Mrs. Esther Herrman, Patron for 30 years,
James J. Higginson, Active Member for 4 years,
John S. Huyler, Active Member for 6 years,
R. P. Lounsberry, Active Member for 6 years,
Col. J. J. McCook, Life Member for 15 years,
Mrs. A. K. Nimick, Life Member for 4 years,
Hon. J. H. Robb, Active Member for 3 years,
Charles Senff, Patron for 16 years.
W. H. J. Sieberg, Active Member for 34 years,
Elliott C. Smith, Active Member for 4 years,
Miss P. Caroline Swords, Life Member for 1 year,
A. H. Wellington, Active Member for 4 years,
Rev. J. L. Zabriskie, Active Member for 1 year.

Respectfully submitted, EDMUND OTIS HOVEY,
Recording Secretary.

REPORT OF THE LIBRARIAN.

The library of the New York Academy of Sciences has received during the year ending December, 1911, through exchange and donation, 375 volumes and 1720 numbers. Important lacunæ have been received from the Tiflisser Physikalischen Observatorium, the Provincial Utrechtsch Genootschap, L'Académie Imperiale des Sciences, Belles-Lettres et Arts de Lyon, the North of England Institute of Mining and Mechanical Engineers, the Real Academia de Ciencias y Artes de Barcelona, the Physikalisch-Medicinische Gesellschaft zu Würzburg and the Naturhistorisk Forening i Kjobenhavn. Special acknowledgments are herewith made to these six institutions for their generosity and assistance in supplying their valuable and much needed publications.

Respectfully submitted, RALPH W. TOWER, *Librarian.*

REPORT OF THE EDITOR.

The Editor reports that during the past fiscal year there were issued Part III, completing Volume XX, and pages 1-175 of Volume XXI.

Respectfully submitted, EDMUND OTIS HOVEY, *Editor.*

REPORT OF THE TREASURER.

RECEIPTS.

DECEMBER 1, 1910—NOVEMBER 30, 1911.

Cash on hand, December 1, 1910		$3,259.74
Income from investments:		
Interest on mortgages on New York City real estate	$860.00	
Interest on railroad and other bonds	1,260.00	
Interest on bank balances	77.08	
		2,197.08
Life membership fee		100.00
Active membership dues, 1909	$45.00	
" " " 1910	165.00	
" " " 1911	3,255.00	
		3,465.00
Associate membership dues, 1910	6.00	
" " " 1911	39.00	
		45.00
Sales of publications		154.24
Subscriptions to annual dinner		106.00
Total		$9,327.06

DISBURSEMENTS.

December 1, 1910—November 30, 1911.

Publications on account of Annals	$2,045.34
Publication of *Bulletin*	510.06
Recording Secretary's expenses	344.68
Recording Secretary's allowance	1,200.00
Lecture Committee	100.00
General expenses	186.50
Esther Herrman Research Fund (grants)	300.00
Headquarters Committee	6.00
Annual meeting and dinner	144.15
Purchase of bonds and commission	3,093.75
Interest charge on bonds purchased	40.00
Cash on hand	1,356.58
Total	$9,327.06

Balance Sheet, November 30, 1911.

Investments (cost)	$41,656.25	Permanent Fund	$22,612.57
Cash on hand	1,356.58	Publication Fund	3,000.00
		Audubon Fund	2,500.00
		Esther Herrman Research Fund	10,000.00
		John Strong Newberry Fund	1,000.00
		Income Permanent Fund	1,565.89
		Income Audubon Fund	202.25
		Income Esther Herrman Fund	1,735.96
		Income Newberry Fund	396.16
	$43,012.83		$43,012.83

3 January, 1912.

Examined and found to be correct,

Charles F. Cox,
Frederic S. Lee,
George F. Kunz,
Auditing Committee.

THE ORGANIZATION OF THE NEW YORK ACADEMY OF SCIENCES

THE ORIGINAL CHARTER

AN ACT TO INCORPORATE THE

LYCEUM OF NATURAL HISTORY IN THE CITY OF NEW YORK

Passed April 20, 1818

WHEREAS, The members of the Lyceum of Natural History have petitioned for an act of incorporation, and the Legislature, impressed with the importance of the study of Natural History, as connected with the wants, the comforts and the happiness of mankind, and conceiving it their duty to encourage all laudable attempts to promote the progress of science in this State—therefore,

1. *Be it enacted by the People of the State of New York represented in Senate and Assembly,* That Samuel L. Mitchill, Casper W. Eddy, Frederick C. Schaeffer, Nathaniel Paulding, William Cooper, Benjamin P. Kissam, John Torrey, William Cumberland, D'Jurco V. Knevels, James Clements and James Pierce, and such other persons as now are, and may from time to time become members, shall be, and hereby are constituted a body corporate and politic, by the name of LYCEUM OF NATURAL HISTORY IN THE CITY OF NEW YORK, and that by that name they shall have perpetual succession, and shall be persons capable of suing and being sued, pleaded and being impleaded, answering and being answered unto, defending and being defended, in all courts and places whatsoever; and may have a common seal, with power to alter the same from time to time; and shall be capable of purchasing, taking, holding, and enjoying to them and their successors, any real estate in fee simple or otherwise, and any goods, chattels, and personal estate, and of selling, leasing, or otherwise disposing of said real or personal estate, or any part thereof, at their will and pleasure: *Provided always,* that the clear annual value or income of such real or personal estate shall not exceed the sum of five thousand dollars: *Provided,* however, that the funds of the said Corporation shall be used and appropriated to the promotion of the objects stated in the preamble to this act, and those only.

2. *And be it further enacted,* That the said Society shall from time to time, forever hereafter, have power to make, constitute, ordain, and establish such by-laws and regulations as they shall judge proper, for the elec-

tion of their officers; for prescribing their respective functions, and the mode of discharging the same; for the admission of new members; for the government of the officers and members thereof; for collecting annual contributions from the members towards the funds thereof; for regulating the times and places of meeting of the said Society; for suspending or expelling such members as shall neglect or refuse to comply with the by-laws or regulations, and for the managing or directing the affairs and concerns of the said Society: *Provided* such by-laws and regulations be not repugnant to the Constitution and laws of this State or of the United States.

3. *And be it further enacted,* That the officers of the said Society shall consist of a President and two Vice-Presidents, a Corresponding Secretary, a Recording Secretary, a Treasurer, and five Curators, and such other officers as the Society may judge necessary; who shall be annually chosen, and who shall continue in office for one year, or until others be elected in their stead; that if the annual election shall not be held at any of the days for that purpose appointed, it shall be lawful to make such election at any other day; and that five members of the said Society, assembling at the place and time designated for that purpose by any by-law or regulation of the Society, shall constitute a legal meeting thereof.

4. *And be it further enacted,* That Samuel L. Mitchill shall be the President; Casper W. Eddy the First Vice-President; Frederick C. Schaeffer the Second Vice-President; Nathaniel Paulding, Corresponding Secretary; William Cooper, Recording Secretary; Benjamin P. Kissam, Treasurer, and John Torrey, William Cumberland, D'Jurco V. Knevels, James Clements, and James Pierce, Curators; severally to be the first officers of the said Corporation, who shall hold their respective offices until the twenty-third day of February next, and until others shall be chosen in their places.

5. *And be it further enacted,* That the present Constitution of the said Association shall, after passing of this Act, continue to be the Constitution thereof: and that no alteration shall be made therein, unless by a vote to that effect of three-fourths of the resident members, and upon the request in writing of one-third of such resident members, and submitted. at least one month before any vote shall be taken thereupon.

State of New York, Secretary's Office.

I CERTIFY the preceding to be a true copy of an original Act of the Legislature of this State, on file in this Office.

ARCH'D CAMPBELL,
Dep. Sec'y.

ALBANY, *April* 20, 1818.

ORDER OF COURT

ORDER OF THE SUPREME COURT OF THE STATE OF NEW YORK TO CHANGE THE NAME OF

THE LYCEUM OF NATURAL HISTORY IN THE CITY OF NEW YORK

TO

THE NEW YORK ACADEMY OF SCIENCES

WHEREAS, in pursuance of the vote and proceedings of this Corporation to change the corporate name thereof from "The Lyceum of Natural History in the City of New York" to "The New York Academy of Sciences," which vote and proceedings appear to record, an application has been made in behalf of said Corporation to the Supreme Court of the State of New York to legalize and authorize such change, according to the statute in such case provided, by Chittenden & Hubbard, acting as the attorneys of the Corporation, and the said Supreme Court, on the 5th day of January, 1876, made the following order upon such application in the premises, viz:

At a special term of the Supreme Court of the State of New York, held at the Chambers thereof, in the County Court House, in the City of New York, the 5th day of January, 1876:

Present—HON. GEO. C. BARRETT, *Justice.*

In the matter of the application of the Lyceum of Natural History in the City of New York to authorize it to assume the corporate name of the New York Academy of Sciences.

On reading and filing the petition of the Lyceum of Natural History in the City of New York, duly verified by John S. Newberry, the President and chief officer of said Corporation, to authorize it to assume the corporate name of the New York Academy of Sciences, duly setting forth

the grounds of said application, and on reading and filing the affidavit of Geo. W. Quackenbush, showing that notice of such application had been duly published for six weeks in the State paper, to wit, *The Albany Evening Journal*, and the affidavit of David S. Owen, showing that notice of such application has also been duly published in the proper newspaper of the County of New York, in which county said Corporation had its business office, to wit, in *The Daily Register*, by which it appears to my satisfaction that such notice has been so published, and on reading and filing the affidavits of Robert H. Browne and J. S. Newberry, thereunto annexed, by which it appears to my satisfaction that the application is made in pursuance of a resolution of the managers of said Corporation to that end named, and there appearing to me to be no reasonable objection to said Corporation so changing its name as prayed in said petition: Now on motion of Grosvenor S. Hubbard, of Counsel for Petitioner, it is

Ordered, That the Lyceum of Natural History in the City of New York be and is hereby authorized to assume the corporate name of The New York Academy of Sciences.

Indorsed: Filed January 5, 1876,

A copy. WM. WALSH, *Clerk*.

Resolution of THE ACADEMY, *accepting the order of the Court, passed February 21, 1876*

And whereas, The order hath been published as therein required, and all the proceedings necessary to carry out the same have been had, Therefore:

Resolved, That the foregoing order be and the same is hereby accepted and adopted by this Corporation, and that in conformity therewith the corporate name thereof, from and after the adoption of the vote and resolution herein above referred to, be and the same is hereby declared to be THE NEW YORK ACADEMY OF SCIENCES.

AMENDED CHARTER

MARCH 19, 1902

CHAPTER 181 OF THE LAWS OF 1902

AN ACT to amend chapter one hundred and ninety-seven of the laws of eighteen hundred and eighteen, entitled "An act to incorporate the Lyceum of Natural History in the City of New York," a Corporation now known as The New York Academy of Sciences and to extend the powers of said Corporation.

(Became a law March 19, 1902, with the approval of the Governor. Passed, three-fifths being present.)

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section I. The Corporation incorporated by chapter one hundred and ninety-seven of the laws of eighteen hundred and eighteen, entitled "An act to incorporate the Lyceum of Natural History in the City of New York," and formerly known by that name, but now known as The New York Academy of Sciences through change of name pursuant to order made by the supreme court at the city and county of New York, on January fifth, eighteen hundred and seventy-six, is hereby authorized and empowered to raise money for, and to erect and maintain, a building in the city of New York for its use, and in which also at its option other scientific societies may be admitted and have their headquarters upon such terms as said Corporation may make with them, portions of which building may be also rented out by said Corporation for any lawful uses for the purposes of obtaining income for the maintenance of such building and for the promotion of the objects of the Corporation; to establish, own, equip, and administer a public library, and a museum having especial reference to scientific subjects; to publish communications, transactions, scientific works, and periodicals; to give scientific instruction by lectures or otherwise; to encourage the advancement of scientific research and discovery, by gifts of money, prizes, or other assistance thereto. The building, or rooms, of said Corporation in the City of New York used exclusively for library or scientific purposes shall be subject to the provisions and be entitled to the benefits of subdivision seven of section four of chapter nine hundred and eight of the laws of eighteen hundred and ninety-six, as amended.

Section II. The said Corporation shall from time to time forever hereafter have power to make, constitute, ordain, and establish such by-laws and regulations as it shall judge proper for the election of its officers; for prescribing their respective functions, and the mode of discharging the same; for the admission of new members; for the government of officers and members thereof; for collecting dues and contributions towards the funds thereof; for regulating the times and places of meeting of said Corporation; for suspending or expelling such members as shall neglect or refuse to comply with the by-laws or regulations, and for managing or directing the affairs or concerns of the said Corporation: and may from time to time alter or modify its constitution, by-laws, rules, and regulations.

SECTION III. The officers of the said Corporation shall consist of a president and two or more vice-presidents, a corresponding secretary, a recording secretary, a treasurer, and such other officers as the Corporation may judge necessary; who shall be chosen in the manner and for the terms prescribed by the constitution of the said Corporation.

SECTION IV. The present constitution of the said Corporation shall, after the passage of this act, continue to be the constitution thereof until amended as herein provided. Such constitution as may be adopted by a vote of not less than three-quarters of such resident members and fellows of the said New York Academy of Sciences as shall be present at a meeting thereof, called by the Recording Secretary for that purpose, within forty days after the passage of this act, by written notice duly mailed, postage prepaid, and addressed to each fellow and resident member at least ten days before such meeting, at his last known place of residence, with street and number when known, which meeting shall be held within three months after the passage of this act, shall be thereafter the constitution of the said New York Academy of Sciences, subject to alteration or amendment in the manner provided by such constitution.

SECTION V. The said Corporation shall have power to consolidate, to unite, to co-operate, or to ally itself with any other society or association in the city of New York organized for the promotion of the knowledge or the study of any science, or of research therein, and for this purpose to receive, hold, and administer real and personal property for the uses of such consolidation, union, co-operation, or alliance subject to such terms and regulations as may be agreed upon with such associations or societies.

SECTION VI. This act shall take effect immediately.

STATE OF NEW YORK,

OFFICE OF THE SECRETARY OF STATE.

I have compared the preceding with the original law on file in this office, and do hereby certify that the same is a correct transcript therefrom, and the whole of said original law.

Given under my hand and the seal of office of the Secretary of State, at the city of Albany, this eighth day of April, in the year one thousand nine hundred and two.

JOHN T. MCDONOUGH,
Secretary of State.

CONSTITUTION

ADOPTED, APRIL 24, 1902, AND AMENDED AT SUBSEQUENT TIMES

ARTICLE I. The name of this Corporation shall be The New York Academy of Sciences. Its object shall be the advancement and diffusion of scientific knowledge, and the center of its activities shall be in the City of New York.

ARTICLE II. The Academy shall consist of five classes of members, namely: Active Members, Fellows, Associate Members, Corresponding Members and Honorary Members. Active Members shall be the members of the Corporation who live in or near the City of New York, or who, having removed to a distance, desire to retain their connection with the Academy. Fellows shall be chosen from the Active Members in virtue of their scientific attainments. Corresponding and Honorary Members shall be chosen from among persons who have attained distinction in some branch of science. The number of Corresponding Members shall not exceed two hundred, and the number of Honorary Members shall not exceed fifty.

ARTICLE III. None but Fellows and Active Members who have paid their dues up to and including the last fiscal year shall be entitled to vote or to hold office in the Academy.

ARTICLE IV. The officers of the Academy shall be a President, as many Vice-Presidents as there are sections of the Academy, a Corresponding Secretary, a Recording Secretary, a Treasurer, a Librarian, an Editor, six elected Councilors and one additional Councilor from each allied society or association. The annual election shall be held on the third Monday in December, the officers then chosen to take office at the first meeting in January following.

There shall also be elected at the same time a Finance Committee of three.

ARTICLE V. The officers named in Article IV shall constitute a Council, which shall be the executive body of the Academy with general control over its affairs, including the power to fill *ad interim* any vacancies that may occur in the offices. Past Presidents of the Academy shall be *ex-officio* members of the Council.

ARTICLE VI. Societies organized for the study of any branch of science may become allied with the New York Academy of Sciences by consent of the Council. Members of allied societies may become Active Members of the Academy by paying the Academy's annual fee, but as

members of an allied society they shall be Associate Members with the rights and privileges of other Associate Members, except the receipt of its publications. Each allied society shall have the right to delegate one of its members, who is also an Active Member of the Academy, to the Council of the Academy, and such delegate shall have all the rights and privileges of other Councilors.

ARTICLE VII. The President and Vice-Presidents shall not be eligible to more than one re-election until three years after retiring from office; the Secretaries and Treasurer shall be eligible to re-election without limitation. The President, Vice-Presidents and Secretaries shall be Fellows. The terms of office of elected Councilors shall be three years, and these officers shall be so grouped that two, at least one of whom shall be a Fellow, shall be elected and two retired each year. Councilors shall not be eligible to re-election until after the expiration of one year.

ARTICLE VIII. The election of officers shall be by ballot, and the candidates having the greatest number of votes shall be declared duly elected.

ARTICLE IX. Ten members, the majority of whom shall be Fellows, shall form a quorum at any meeting of the Academy at which business is transacted.

ARTICLE X. The Academy shall establish by-laws, and may amend them from time to time as therein provided.

ARTICLE XI. This Constitution may be amended by a vote of not less than three-fourths of the fellows and three-fourths of the active members present and voting at a regular business meeting of the Academy, provided that such amendment shall be publicly submitted in writing at the preceding business meeting, and provided also that the Recording Secretary shall send a notice of the proposed amendment at least ten days before the meeting, at which a vote shall be taken, to each Fellow and Active Member entitled to vote.

BY-LAWS

AS ADOPTED, OCTOBER 6, 1902, AND AMENDED AT SUBSEQUENT TIMES

CHAPTER I

OFFICERS

1. *President.* It shall be the duty of the President to preside at the business and special meetings of the Academy; he shall exercise the customary duties of a presiding officer.

2. *Vice-Presidents.* In the absence of the President, the senior Vice-President, in order of Fellowship, shall act as the presiding officer.

3. *Corresponding Secretary.* The Corresponding Secretary shall keep a corrected list of the Honorary and Corresponding Members, their titles and addresses, and shall conduct all correspondence with them. He shall make a report at the Annual Meeting.

4. *Recording Secretary.* The Recording Secretary shall keep the minutes of the Academy proceedings; he shall have charge of all documents belonging to the Academy, and of its corporate seal, which he shall affix and attest as directed by the Council; he shall keep a corrected list of the Active Members and Fellows, and shall send them announcements of the Meetings of the Academy; he shall notify all Members and Fellows of their election, and committees of their appointment; he shall give notice to the Treasurer and to the Council of matters requiring their action, and shall bring before the Academy business presented by the Council. He shall make a report at the Annual Meeting.

5. *Treasurer.* The Treasurer shall have charge, under the direction of the Council, of all moneys belonging to the Academy, and of their investment. He shall receive all fees, dues and contributions to the Academy, and any income that may accrue from property or investment; he shall report to the Council at its last meeting before the Annual Meeting the names of members in arrears; he shall keep the property of the Academy insured, and shall pay all debts against the Academy the discharge of which shall be ordered by the Council. He shall report to the Council from time to time the state of the finances, and at the Annual Meeting shall report to the Academy the receipts and expenditures for the entire year.

6. *Librarian.* The Librarian shall have charge of the library, under the general direction of the Library Committee of the Council, and shall conduct all correspondence respecting exchanges of the Academy. He shall make a report on the condition of the library at the Annual Meeting.

7. *Editor.* The editor shall have charge of the publications of the Academy, under the general direction of the Publication Committee of the Council. He shall make a report on the condition of the publications at the Annual Meeting.

CHAPTER II

COUNCIL

1. *Meetings.* The Council shall meet once a month, or at the call of the President. It shall have general charge of the affairs of the Academy.

2. *Quorum.* Five members of the Council shall constitute a quorum.

3. *Officers.* The President, Vice-Presidents and Recording Secretary of the Academy shall hold the same offices in the Council.

4. *Committees.* The Standing Committees of the Council shall be: (1) an Executive Committee consisting of the President, Treasurer, and Recording Secretary; (2) a Committee on Publication; (3) a Committee on the Library, and such other committees as from time to time shall be authorized by the Council. The action of these committees shall be subject to revision by the Council.

Chapter III

FINANCE COMMITTEE

The Finance Committee of the Academy shall audit the Annual Report of the Treasurer, and shall report on financial questions whenever called upon to do so by the Council.

Chapter IV

ELECTIONS

1. *Active Members.* (*a*) Active Members shall be nominated in writing to the Council by at least two Active Members or Fellows. If approved by the Council, they may be elected at the succeeding business meeting.

(*b*) Any Active Member who, having removed to a distance from the city of New York, shall nevertheless express a desire to retain his connection with the Academy, may be placed by vote of the Council on a list of Non-Resident Members. Such members shall relinquish the full privileges and obligations of Active Members. (*Vide* Chapters V and X.)

2. *Associate Members.* Workers in science may be elected to Associate Membership for a period of two years in the manner prescribed for Active Members. They shall not have the power to vote and shall not be eligible to election as Fellows, but may receive the publications. At any time subsequent to their election they may assume the full privileges of Active Members by paying the dues of such Members.

3. *Fellows, Corresponding Members and Honorary Members.* Nominations for Fellows, Corresponding Members and Honorary Members may be made in writing either to the Recording Secretary or to the Council at its meeting prior to the Annual Meeting. If approved by the Council, the nominees shall then be balloted for at the Annual Meeting.

4. *Officers.* Nominations for Officers, with the exception of Vice-Presidents, may be sent in writing to the Recording Secretary, with the name of the proposer, at any time not less than thirty days before the Annual Meeting. Each section of the Academy shall nominate a candi-

date for Vice-President, who, on election, shall be Chairman of the section; the names of such nominees shall be sent to the Recording Secretary properly certified by the sectional secretaries, not less than thirty days before the Annual Meeting. The Council shall then prepare a list which shall be the regular ticket. This list shall be mailed to each Active Member and Fellow at least one week before the Annual Meeting. But any Active Member or Fellow entitled to vote shall be entitled to prepare and vote another ticket.

Chapter V

DUES

1. *Dues.* The annual dues of Active Members and Fellows shall be $10, payable in advance at the time of the Annual Meeting; but new members elected after May 1, shall pay $5 for the remainder of the fiscal year.

The annual dues of elected Associate Members shall be $3, payable in advance at the time of the Annual Meeting.

Non-Resident Members shall be exempt from dues, so long as they shall relinquish the privileges of Active Membership. (*Vide* Chapter X.)

2. *Members in Arrears.* If any Active Member or Fellow whose dues remain unpaid for more than one year, shall neglect or refuse to pay the same within three months after notification by the Treasurer, his name may be erased from the rolls by vote of the Council. Upon payment of his arrears, however, such person may be restored to Active Membership or Fellowship by vote of the Council.

3. *Renewal of Membership.* Any Active Member or Fellow who shall resign because of removal to a distance from the city of New York, or any Non-Resident Member, may be restored by vote of the Council to Active Membership or Fellowship at any time upon application.

Chapter VI

PATRONS, DONORS AND LIFE MEMBERS

1. *Patrons.* Any person contributing at one time $1,000 to the general funds of the Academy shall be a Patron and, on election by the Council, shall enjoy all the privileges of Active Members.

2. *Donors.* Any person contributing $50 or more annually to the general funds of the Academy shall be termed a Donor and, on election by the Council, shall enjoy all the privileges of an Active Member.

3. *Life Members.* Any Active Member or Fellow contributing at one time $100 to the general funds of the Academy shall be a Life Member

and shall thereafter be exempt from annual dues; and any Active Member or Fellow who has paid annual dues for twenty-five years or more may, upon his written request, be made a life member and be exempt from further payment of dues.

Chapter VII

SECTIONS

1. *Sections.* Sections devoted to special branches of Science may be established or discontinued by the Academy on the recommendation of the Council. The present sections of the Academy are the Section of Astronomy, Physics and Chemistry, the Section of Biology, the Section of Geology and Mineralogy and the Section of Anthropology and Psychology.

2. *Organization.* Each section of the Academy shall have a Chairman and a Secretary, who shall have charge of the meetings of their Section. The regular election of these officers shall take place at the October or November meeting of the section, the officers then chosen to take office at the first meeting in January following.

3. *Affiliation.* Members of scientific societies affiliated with the Academy, and members of the Scientific Alliance, or men of science introduced by members of the Academy, may attend the meetings and present papers under the general regulations of the Academy.

Chapter VIII

MEETINGS

1. *Business Meetings.* Business meetings of the Academy shall be held on the first Monday of each month from October to May inclusive.

2. *Sectional Meetings.* Sectional meetings shall be held on Monday evenings from October to May inclusive, and at such other times as the Council may determine. The sectional meeting shall follow the business meeting when both occur on the same evening.

3. *Annual Meeting.* The Annual Meeting shall be held on the third Monday in December.

4. *Special Meetings.* A special meeting may be called by the Council, provided one week's notice be sent to each Active Member and Fellow, stating the object of such meeting.

CHAPTER IX

ORDER OF BUSINESS

1. *Business Meetings.* The following shall be the order of procedure at business meetings:

    1. Minutes of the previous business meeting.
    2. Report of the Council.
    3. Reports of Committees.
    4. Elections.
    5. Other business.

2. *Sectional Meetings.* The following shall be the order of procedure at sectional meetings:

    1. Minutes of the preceding meeting of the section.
    2. Presentation and discussion of papers.
    3. Other scientific business.

3. *Annual Meetings.* The following shall be the order of procedure at Annual Meetings:

    1. Annual reports of the Corresponding Secretary, Recording Secretary, Treasurer, Librarian, and Editor.
    2. Election of Honorary Members, Corresponding Members, and Fellows.
    3. Election of officers for the ensuing year.
    4. Annual address of the retiring President.

CHAPTER X

PUBLICATIONS

1. *Publications.* The established publications of the Academy shall be the *Annals* and the *Memoirs.* They shall be issued by the Editor under the supervision of the Committee on Publications.

2. *Distribution.* One copy of all publications shall be sent to each Patron, Life Member, Active Member and Fellow; *provided,* that upon inquiry by the Editor such Members or Fellows shall signify their desire to receive them.

3. *Publication Fund.* Contributions may be received for the publication fund, and the income thereof shall be applied toward defraying the expenses of the scientific publications of the Academy.

Chapter XI

GENERAL PROVISIONS

1. *Debts.* No debts shall be incurred on behalf of the Academy, unless authorized by the Council.

2. *Bills.* All bills submitted to the Council must be certified as to correctness by the officers incurring them.

3. *Investments.* All the permanent funds of the Academy shall be invested in United States or in New York State securities or in first mortgages on real estate, provided they shall not exceed sixty-five per cent. of the value of the property, or in first-mortgage bonds of corporations which have paid dividends continuously on their common stock for a period of not less than five years. All income from patron's fees, life-membership fees and donor's fees shall be added to the permanent fund.

4. *Expulsion, etc.* Any Member or Fellow may be censured, suspended or expelled, for violation of the Constitution or By-Laws, or for any offence deemed sufficient, by a vote of three-fourths of the Members and three-fourths of the Fellows present at any business meeting, provided such action shall have been recommended by the Council at a previous business meeting, and also, that one month's notice of such recommendation and of the offence charged shall have been given the Member accused.

5. *Changes in By-Laws.* No alteration shall be made in these By-Laws unless it shall have been submitted publicly in writing at a business meeting, shall have been entered on the Minutes with the names of the Members or Fellows proposing it, and shall be adopted by two-thirds of the Members and Fellows present and voting at a subsequent business meeting.

MEMBERSHIP OF THE

NEW YORK ACADEMY OF SCIENCES

HONORARY MEMBERS

31 December, 1911

Elected.

1898. Arthur Auwers, Berlin, Germany.
1889. Charles Barrois, Lille, France.
1907. William Bateson, Cambridge, England.
1910. Theodor Boveri, Würzburg, Germany.
1901. Charles Vernon Boys, London, England.
1904. W. C. Brögger, Christiana, Norway.
1911. Hermann Credner, Leipzig, Germany.
1899. Sir George Howard Darwin, Cambridge, England.
1876. W. Boyd Dawkins, Manchester, England.
1902. Sir James Dewar, Cambridge, England.
1901. Emil Fischer, Berlin, Germany.
1876. Sir Archibald Geikie, Haslemere, Surrey, England.
1901. James Geikie, Edinburgh, Scotland.
1898. Sir David Gill, London, England.
1909. K. F. Göbel, Munich, Germany.
1889. George Lincoln Goodale, Cambridge, Mass.
1909. Paul von Groth, Munich, Germany.
1894. Ernst Häckel, Jena, Germany.
1899. Julius Hann, Vienna, Austria.
1898. George W. Hill, West Nyack, N. Y.
1907. Sir Joseph D. Hooker, Kew, England.
1896. Ambrosius A. W. Hubrecht, Utrecht, Netherlands.
1896. Felix Klein, Göttingen, Germany.
1909. Alfred Lacroix, Paris, France.
1876. Viktor von Lang, Vienna, Austria.
1898. E. Ray Lankester, London, England.
1880. Sir Norman Lockyer, London, England.
1900. Franz Leydig, Tauber, Germany.
1911. Ernst Mach, Vienna, Austria.
1898. Fridtjof Nansen, Christiana, Norway.
1908. Wilhelm Ostwald, Gross-Bothen, Germany.
1898. Albrecht Penck, Berlin, Germany.
1898. Wilhelm Pfeffer, Leipzig, Germany.
1900. Edward Charles Pickering, Cambridge, Mass.

ELECTED.

1900. JULES HENRI POINCARÉ, Paris, France.
1911. EDWARD BAGNALL POULTON, Oxford, England.
1901. Sir WILLIAM RAMSAY, London, England.
1899. Lord RAYLEIGH, Witham, Essex, England.
1898. HANS H. REUSCH, Christiana, Norway.
1887. Sir HENRY ENFIELD ROSCOE, London, England.
1887. HEINRICH ROSENBUSCH, Heidelberg, Germany.
1904. KARL VON DEN STEINEN, Berlin, Germany.
1908. EDUARD STRASBURGER, Bonn, Germany.
1896. JOSEPH JOHN THOMSON, Cambridge, England.
1900. EDWARD BURNETT TYLOR, Oxford, England.
1904. HUGO DE VRIES, Amsterdam, Netherlands.
1907. JAMES WARD, Cambridge, England.
1909. AUGUST WEISSMANN, Freiburg, Germany.
1904. WILHELM WUNDT, Leipzig, Germany.
1904. FERDINAND ZIRKEL, Leipzig, Germany.

CORRESPONDING MEMBERS

31 DECEMBER, 1911

1883. CHARLES CONRAD ABBOTT, Trenton, N. J.
1898. FRANK D. ADAMS, Montreal, Canada.
1891. JOSÉ G. AGUILERA, Mexico City, Mexico.
1890. WILLIAM DE WITT ALEXANDER, Honolulu, Hawaii.
1899. C. W. ANDREWS, London, England.
1876. JOHN HOWARD APPLETON, Providence, R. I.
1899. J. G. BAKER, Kew, England.
1898. ISAAC BAGLEY BALFOUR, Edinburgh, Scotland.
1878. ALEXANDER GRAHAM BELL, Washington, D. C.
1867. EDWARD L. BERTHOUD, Golden, Colo.
1897. HERBERT BOLTON, Bristol, England.
1899. G. A. BOULENGER, London, England.
1874. T. S. BRANDEGEE, San Diego, Calif.
1884. JOHN C. BRANNER, Stanford University, Calif.
1894. BOHUSLAY BRAUNER, Prague, Bohemia.
1874. WILLIAM BREWSTER, Cambridge, Mass.
1876. GEORGE JARVIS BRUSH, New Haven, Conn.
1898. T. C. CHAMBERLIN, Chicago, Ill.
1876. FRANK WIGGLESWORTH CLARKE, Washington, D. C.
1891. L. CLERC, Ekaterinburg, Russia.

ELECTED.

1877. THEODORE B. COMSTOCK, Los Angeles, Calif.
1868. M. C. COOKE, London, England.
1876. H. B. CORNWALL, Princeton, N. J.
1880. CHARLES B. CORY, Boston, Mass.
1877. JOSEPH CRAWFORD, Philadelphia, Pa.
1895. HENRY P. CUSHING, Cleveland, O.
1879. T. NELSON DALE, Pittsfield, Mass.
1870. WILLIAM HEALEY DALL, Washington, D. C.
1885. EDWARD SALISBURY DANA, New Haven, Conn.
1898. WILLIAM M. DAVIS, Cambridge, Mass.
1894. RUTHVEN DEANE, Chicago, Ill.
1899. CHARLES DÉPERET, Lyons, France.
1890. ORVILLE A. DERBY, Rio de Janeiro, Brazil.
1899. LOUIS DOLLO, Brussels, Belgium.
1876. HENRY W. ELLIOTT, Lakewood, O.
1880. JOHN B. ELLIOTT, New Orleans, La.
1869. FRANCIS E. ENGELHARDT, Syracuse, N. Y.
1879. HERMAN LE ROY FAIRCHILD, Rochester, N. Y.
1879. FRIEDRICH BERNHARD FITTICA, Marburg, Germany.
1885. LAZARUS FLETCHER, London, England.
1899. EBERHARD FRAAS, Stuttgart, Germany.
1879. REINHOLD FRITZGARTNER, Tegucigalpa, Honduras.
1870. GROVE K. GILBERT, Washington, D. C.
1858. THEODORE NICHOLAS GILL, Washington, D. C.
1865. CHARLES A. GOESSMAN, Amherst, Mass.
1888. FRANK AUSTIN GOOCH, New Haven, Conn.
1868. C. R. GREENLEAF, San Francisco, Calif.
1883. Marquis ANTONIO DE GREGORIO, Palermo, Sicily.
1869. R. J. LECHMERE GUPPY, Trinidad, British West Indies.
1898. GEORGE E. HALE, Mt. Wilson, Calif.
1882. Baron ERNST VON HESSE-WARTEGG, Lucerne, Switzerland.
1867. C. H. HITCHCOCK, Honolulu, H. I.
1900. WILLIAM HENRY HOLMES, Washington, D. C.
1890. H. D. HOSKOLD, Buenos Ayres, Argentine Republic.
1896. J. P. IDDINGS, Brinklow, Md.
1875. MALVERN W. ILES, Dubuque, Ia.
1899. OTTO JÄCKEL, Greifswald, Germany.
1876. DAVID STARR JORDAN, Stanford University, Calif.
1876. GEORGE A. KOENIG, Houghton, Mich.
1888. Baron R. KUKI, Tokyo, Japan.

ELECTED.

1876. JOHN W. LANGLEY, Cleveland, O.
1876. S. A. LATTIMORE, Rochester, N. Y.
1894. WILLIAM LIBBEY, Princeton, N. J.
1899. ARCHIBALD LIVERSIDGE, London, England.
1876. GEORGE MACLOSKIE, Princeton, N. J.
1876. JOHN WILLIAM MALLET, Charlottesville, Va.
1891. CHARLES RIBORG MANN, Chicago, Ill.
1867. GEORGE F. MATTHEW, St. John, N. B., Canada.
1874. CHARLES JOHNSON MAYNARD, West Newton, Mass.
1874. THEODORE LUQUEER MEAD, Oviedo, Fla.
1888. SETH E. MEEK, Chicago, Ill.
1892. J. DE MENDIZÁBAL-TAMBORREL, Mexico City, Mexico.
1874. CLINTON HART MERRIAM, Washington, D. C.
1898. MANSFIELD MERRIAM, South Bethlehem, Pa.
1878. CHARLES SEDGWICK MINOT, Boston, Mass.
1876. WILLIAM GILBERT MIXTER, New Haven, Conn.
1890. RICHARD MOLDENKE, Watchung, N. J.
1895. C. LLOYD MORGAN, Bristol, England.
1864. EDWARD S. MORSE, Salem, Mass.
1898. GEORGE MURRAY, London, England.
——. EUGEN NETTO, Giessen, Germany.
1866. ALFRED NEWTON, Cambridge, England.
1897. FRANCIS C. NICHOLAS, New York, N. Y.
1882. HENRY ALFRED ALFORD NICHOLLS, Dominica, B. W. I.
1880. EDWARD J. NOLAN, Philadelphia, Pa.
1879. FREDERICK A. OBER, Hackensack, N. J.
1876. JOHN M. ORDWAY, New Orleans, La.
1900. GEORGE HOWARD PARKER, Cambridge, Mass.
1876. STEPHEN F. PECKHAM, New York, N. Y.
1877. FREDERICK PRIME, Philadelphia, Pa.
1868. RAPHAEL PUMPELLY, Newport, R. I.
1876. B. ALEX. RANDALL, Philadelphia, Pa.
1876. IRA REMSEN, Baltimore, Md.
1874. ROBERT RIDGWAY, Washington, D. C.
1886. WILLIAM L. ROBB, Troy, N. Y.
1876. SAMUEL P. SADTLER, Philadelphia, Pa.
1899. D. MAX SCHLOSSER, Munich, Germany.
1867. PAUL SCHWEITZER, Columbia, Mo.
1898. W. B. SCOTT, Princeton, N. J.
1894. W. T. SEDGWICK, Boston, Mass.

ELECTED.

1876. Andrew Sherwood, Portland, Ore.
1883. J. Ward Smith, Newark, N. J.
1895. Charles H. Smyth, Jr., Princeton, N. J.
1890. J. Selden Spencer, Tarrytown, N. Y.
1896. Robert Stearns, Los Angeles, Calif.
1890. Walter Le Conte Stevens, Lexington, Va.
1876. Francis H. Storer, Boston, Mass.
1885. Rajah Sourindro Mohun Tagore, Calcutta, India.
1893. J. P. Thomson, Brisbane, Queensland, Australia.
1899. R. H. Traquair, Colinton, Scotland.
1877. John Trowbridge, Cambridge, Mass.
1876. D. K. Tuttle, Philadelphia, Pa.
1871. Henri Van Heurck, Antwerp, Belgium.
1900. Charles R. Van Hise, Madison, Wis.
1867. Addison Emery Verrill, New Haven, Conn.
1890. Anthony Wayne Vogdes, San Diego, Calif.
1898. Charles Doolittle Walcott, Washington, D. C.
1876. Leonard Waldo, New York, N. Y.
1900. Sho Watasé, Tokyo, Japan.
1897. Stuart Weller, Chicago, Ill.
1874. I. C. White, Morgantown, W. Va.
1898. Henry Shaler Williams, Ithaca, N. Y.
1898. N. H. Winchell, Minneapolis, Minn.
1866. Horatio C. Wood, Philadelphia, Pa.
1899. A. Smith Woodward, London, England.
1876. Arthur Williams Wright, New Haven, Conn.
1876. Harry Crècy Yarrow, Washington, D. C.

ACTIVE MEMBERS

1911

Fellowship is indicated by an asterisk (*) before the name; Life Membership, by a dagger (†); Patronship, by a section mark (§).

*Abbe, Dr. Cleveland
Abercrombie, David T.
†Adams, Edward D.
Agens, F. G., Sr.
†Alexander, Chas. B.
*Allen, J. A., Ph.D.
Allen, James Lane
*†Allis, Edward Phelps, Jr., Ph.D.
Ames, Oakes
Anderson, A. A.
Anderson, A. J. C.
*Andrews, Roy C.
†Anthony, R. A.
Arend, Francis J.
†Armstrong, S. T., M.D.
Arnold, Felix, M.D.
Ashby, George E.
Astor, John Jacob
Avery, Samuel P.
†Bailey, James M.
†Barhydt, Mrs. P. H.
*Barnhart, John Hendley
Barron, George D.
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